VOLUME XXX AUGUST, 1941 NUMBER 3

THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS: SERIES A

CONTENTS

Published by
THE COLLEGE OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES

The Philippine Agriculturist

(University of the Philippines Publications: Series A)

THE PHILIPPINE AGRICULTURIST is published monthly, except in April and May, by the College of Agriculture, University of the Philippines, Los Baños, Laguna. The subscription price is ₱4.00 a year in the Philippines and $2.50 elsewhere; the price of single copies, 40 centavos in the Philippines and 25 cents elsewhere.

Business correspondence should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, Agricultural College, Laguna, Philippines. All remittances should be made payable to THE PHILIPPINE AGRICULTURIST.

Communications for the editor should be addressed to the Editor, THE PHILIPPINE AGRICULTURIST, Agricultural College, Laguna, Philippines.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed: Library, College of Agriculture, Agricultural College, Laguna, Philippines.

Entered at the Post Office at Agricultural College, Laguna, Philippines, as second-class mail matter.

AGRICULTURAL EDUCATION IN AUSTRALIA[1]

F. M. FRONDA
Of the Department of Animal Husbandry

Vocational agriculture is taught in Australia in the so-called agricultural college and is under the supervision of the State Department of Agriculture. Agricultural science is taught by the Faculty of Agriculture attached to the State University of which each state has one. For admission to the agricultural college, presentation of the Intermediate Certificate issued by the Department of Education, or its equivalent, is required. To be admitted to the Faculty of Agriculture in the University, an applicant must pass all the required subjects at the public examinations conducted by the University annually.

Applicants for admission to the Faculty of Agriculture in the University of Queensland, if they have already attained the age of twenty-five years, may be admitted upon passing only a special examination. In the Faculty of Agriculture in the University of Melbourne, candidates for admission are advised to take in the intermediate school examination the following subjects: Algebra, geometry, and trigonometry, and German or French. A knowledge of physics and chemistry is also advisable.

The Hawkesbury Agricultural College. The curriculum of this college is a typical example of the vocational course in agriculture. The Hawkesbury Agricultural College was established by the Department of Agriculture of New South Wales "to teach the science of agriculture and the various sciences connected therewith, and their practical application. The chief aim is to turn out men who will take up farming and grazing as a vocation". The courses given in this college are both theoretical and practical and are of collegiate standing. All students are boarded by the College.

The students are trained for the successful management of cattle and sheep stations, mixed farms, irrigation farms, dairy, piggery, and poultry farms, orchards, vineyards, and apiaries, and for posi-

[1] General contribution No. 780.

tions on the field staff of the Department of Agriculture. The students are also prepared for positions as dairy factory managers, butter-makers, cheese-makers, milk testers, and dairy instructors. Those who intend to obtain a thorough knowledge of agriculture and livestock and their various branches to take up practical farming, teaching, or instructional work as a profession pursue a three-year course that leads to the Hawkesbury Diploma in Agriculture (H.D.A.) while those who desire to become dairy factory managers and instructors pursue the two-year course leading to the Hawkesbury Diploma in Dairying (H.D.D.)

The curriculum. In the agricultural course, the subjects treated in the first year include agriculture (part 1), livestock (part 1), agricultural chemistry and soil physics, (theoretical and practical—part 1), botany (theoretical and practical), business principles and farm meteorology, economic entomology (theoretical and practical), and farm mechanics. In addition to these, practical instruction classes are held in agriculture, livestock, carpentry, saddlery, blacksmithing and mechanics. The mornings of Tuesday, Thursdays, and Saturdays, and part of Mondays and Fridays are devoted to practical work on the farm. Here the students are given instruction in the handling and harnessing of horses, and in the use, construction, and care of farm implements.

During the second year, the subjects that are given include agriculture (part 2), agricultural economics (part 1), livestock (part 2), agricultural chemistry and soil physics (theoretical and practicals—part 2), plant pathology (theoretical and practical), farm bookkeeping, sheep and wool (part 1), farm surveying, elementary veterinary science (part 1), agricultural bacteriology, farm engineering, and farm dairy. The mornings of Mondays, Wednesdays, Fridays, and Saturdays of each week are devoted to practical work on the farm. They take part in all field operations and participate in the practical work connected with the management and rearing of cows, pigs, poultry, horses, and sheep, and in addition, they receive training at the saddlery, smithy, engineering, carpenter's, and wheelright's shops.

The third-year subjects include agriculture (part 3), agricultural economics (part 2), livestock (part 3), economic botany (theoretical and practical), elementary veterinary science (part 2), and sheep and wool (part 2). Tuesday, Wednesday, Thursday, and Saturday mornings of each week are devoted to practical work on

the farm. The students at this stage are entrusted to carry out and control the various operations on the farm. All students in the third year are required to join in the educational tour of the western, southern, and northwestern districts of the state.

Of the courses listed in the curriculum, a number may be of interest to us in the Philippines. These include agriculture and livestock, subjects that are given in all the three years of the diploma course, soil physics, given during the first two years, farm meteorology, given during the first, and agricultural bacteriology given in the second.

Agriculture 1 covers (*a*) agricultural geography and (*b*) principles of agriculture which include soils, crops, pastures, dairying, and orcharding. Agriculture 2, in addition to pastures, crops, dairying and orcharding, covers plant improvement; while Agriculture 3, in addition to pastures, dairying and orcharding, also contains in its syllabus farm management, tropical crops, and experiment work, that is, conducting experiments and interpretation of the results obtained.

Livestock 1 is an introductory course, covering an elementary study of horses, sheep, poultry, and pigs. In the second year, Livestock 2 includes pigs, cattle, horses, and poultry. Livestock 3 is animal nutrition where the principles of feeds and feeding farm animals are discussed.

Soil physics given to the first year students covers the origin of the soil, general character of soils formed from various rock formations, the mineral constituents of soils, physical properties of the soil, the organic constituents, and the aëration of soils. In the second year, moisture and control of soil moisture, temperature of the soil, acidity, and the treatment of alkali soils are taken up.

In agricultural bacteriology, the structure and classification of bacteria, yeasts, and molds are taken up. The influence on micro-organic life of moisture, food substances, heat and cold, light, pressure, excretory substances, disinfectants, and electricity is discussed. This course also includes a study of general microbiology, dairy microbiology, and the micro-organisms in water and septic tanks.

Farm meteorology is a lecture course. In a country like the Philippines, a course similar to this should prove interesting and well worth the effort. The course as given at the Hawkesbury Agricultural College covers a study of the apparatus and methods used in weather observations, air temperature and pressure, winds and

storms, precipitation, weather, and climate in relation to crops, plant phenology, weather signs and forecasts.

Graduation of students. At the end of the second and third years of schooling, comprehensive examinations on all the subjects are given. Passing these examinations will entitle the student to the academic distinction of Hawkesbury Diploma in Agriculture (H. D. A.). Honors are awarded at graduation as follows: first class honors are awarded to those students who obtain 78 per cent and over the possible marks computed by adding one-third of the total marks obtained in the second-year examination and two-thirds of those obtained in the third year. If the student obtains 70 per cent, but less than 78 per cent of the possible marks, he is awarded second class hours. The student who obtains first place is the DUX in Agriculture, a term that corresponds to *valedictorian* in our schools in the Philippines.

The Faculty of Agriculture. The degree course in agriculture covers a period of four years after admission to the Faculty of Agriculture. It is intended for those who desire to take up agricultural science as a profession. Graduates may become research workers, teachers, field instructors, technical experts with commercial firms, and agricultural journalists.

Students who hold the diploma in agriculture with honors and who have passed the intermediate certificate examination in the entrance subjects; namely, English, another language, Mathematics I and II, and another entrance subject, may be admitted to the University as a regular student, either in the Faculty of Agriculture or in the Faculty of Veterinary Science. These students may be permitted to take the degree of Bachelor of Science in Agriculture in three years only by omitting certain subjects from the third and fourth years of the University course.

To qualify for the degree of Bachelor of Agricultural Science, the candidate must pass the intermediate examination in biology, physics, chemistry and organic chemistry, and the professional examination which covers all the subjects given in the curriculum.

The curricula are practically the same in all the universities visited. The freshman courses include the fundamental sciences of chemistry, physics or natural philosophy, as it is sometimes called, botany or biology, zoology, mathematics; and in the University of Queensland, also geology. During the succeeding years, the studies cover subjects like agriculture, agricultural geology, agricultural en-

tomology, wool classing, elementary organic chemistry, agricultural botany, agricultural biochemistry, agricultural engineering and surveying, plant pathology, agricultural bacteriology, horticultural science and practices, parasitology and veterinary dietetics, genetics and plant breeding, dairy technology, principles of viticulture, agricultural economics and farm bookkeeping, applied agrostology and pasture management, and meteorology.

Of interest to our agricultural students in the Philippines is that practical work is required of all such students in Australia. In all colleges visited, practical farm work is emphasized. In the University of Melbourne, during the second year the students of the Faculty of Agriculture go into residence at the State Research Farm in Werribee where they attend lectures and demonstrations and perform such practical work as may be prescribed by the faculty. In the University of Queensland, the agricultural students engage in such field work as may be prescribed at the Queensland Agricultural High School and College or elsewhere during the vacation between the first and second years. During the vacation between the second and third years and between the third and fourth years, the student engages in field work or such other work as may be prescribed.

SUMMARY

1. Instruction in vocational agriculture in Australia is being given in agricultural colleges under the supervision of the State Department of Agriculture. Agricultural science as a profession is taught by the Faculty of Agriculture attached to the State University.

2. Completion of the three-year course in the agricultural college leads to a diploma in agriculture, while completion of the four-year course in the Faculty of Agriculture leads to the degree of Bachelor of Agricultural Science.

3. The courses offered in the agricultural colleges are both theoretical and practical and are of collegiate standing. In both the agricultural college and the Faculty of Agriculture, practical farm work is emphasized.

INTRODUCTION AND TRIAL CULTURE OF JAVA NEPHELIUMS IN THE COLLEGE OF AGRICULTURE[1]

N. B. MENDIOLA
Of the Department of Agronomy

WITH FOUR PLATES AND TWO TEXT FIGURES

The Philippine sapindaceous fruit species are practically all wild and very little attempt has been made to cultivate them. The College of Agriculture, the Lamao Station of the Bureau of Plant Industry, and a few private individuals have grown under cultivation such species as the kubili, *Cubilia blancoi* Blume, and the alupag, *Euphoria didyma* Blanco, but even in these cases only few trees have been planted. The main reason for the failure of the Philippine sapindaceous plants to be in general cultivation is the fact that the fruits of such trees have very thin flesh which is generally sour and does not separate readily from the seed. The kubili, in reality a nut species, has some good points to recommend it as a substitute for chestnut, but it does not have as good a keeping quality.

The litchi, *Litchi sinensis* Sonn. and the longan, *Euphoria longana* Lamk have been introduced into the Philippines very many years ago. However, the litchi has not fruited in this country and only two trees of the longan have so far been reported to have fruited here. The introduction into the Philippines of desirable varieties of *Nephelium* (also of the family Sapindaceae) from abroad must be considered an important plant breeding and pomological work.

Species of *Nephelium* are found in many tropical countries such as Burma, Indo-China, Malay Peninsula, Sumatra, Borneo, Java, and the Philippines. Little or nothing is known in the Philippines about the merit of the nepheliums of foreign countries and no attempt to introduce them here has been made except those from Java. According to Heyne (1927), there are seven species of *Nephelium* in Java; namely, *N. mutabile*, *N. lappaceum*, *N. costatum* Hiern., *N. eriopetalum* Miq., *N. hamulatum* Radlk., *N. maingayi* Hiern., and *N. malaiense* Griff. Of these, only four may be considered fruit species,—*N. mutabile*, *N. lappaceum*, *N. maingayi*, and *N. malaiense*.

[1] Experiment Station contribution No. 1430. The data covered by this paper up to October 25, 1934, were read on this date in the Los Baños Biological Club.

The fruit of *N. maingayi* is very sour whereas that of *N. malaiense* is too small to be of any commercial promise. In Java the other two species, *N. mutabile* and *N. lappaceum,* include certain excellent forms which had not been found in the Philippines until some of them were introduced here. There is a fair-sized rambutan and kapulasan industry in Java. Fruits of these plants are not only consumed within the country but quantities of them have been exported to other islands of the Dutch East Indies as well as to Singapore and Europe.

MATERIALS AND EXPERIMENTS

Materials

The species under report are *Nephelium lappaceum* and *N. mutabile* of Java. *Nephelium lappaceum* is called *ramboetan* by the Javanese. In the Philippines, the names reported for this species are *usare* and *usau* both supposedly of the Sulu dialect. In Philippine horticultural literature, the Malay name *rambutan* has been applied to this fruit more prominently than the Philippine names. The author believes that rambutan should be adopted as the Philippine common name also. Rambutan is cultivated in Java as a fruit tree in lower districts at places not above 300 meters elevation from sea level. The Javanese used to extract an edible fat with low melting point from its seed.

Nephelium mutabile is called *kapoelasan,* or *poelasan,* in Java. According to Merrill (1923), several names are applied in the Philippines to *Nephelium mutabile* plants, one of which is *bulala.* Inasmuch as we have adopted the name "rambutan" for *N. lappaceum* and the Java *N. mutabile* of this work is apparently different from our bulala, we shall retain "kapulasan" for *N. mutabile.* It is so used in Dutch literature, though spelled "kapoelasan" following the Dutch style.

In Java, *N. mutabile* is only cultivated in the western part of the Island at 110 to 300 meters elevation. The fruits are in great demand. Lamp oil which is also edible is similar to the rambutan oil. Kapulasan fruits are produced in the districts near the city of Batavia. The very best specimens are said to come from a small area with an elevation of 230 to 300 meters above sea level.

The rainfall near Batavia as recorded by Station Meester Cornelis and Pasar Mingoe and compared with that in the College of Agriculture, Los Baños, is shown in table 1. The table shows that the total rainfall in the Java nephelium area is about the same as

that in this College, although that of Java is more uniformly distributed throughout the year than the local rainfall.

The distinguishing morphological characters of *N. mutabile* and *N. lappaceum* of Java are given by Backer (1907). The varieties of *Nephelium lappaceum* in Java are given by Heyne (1927), and Backer (1907). Their lists do not include variety Atjeh Rapia which has been reported as a new variety and the best.

The varieties of *N. mutabile* in Java are the Merah, Poetih, also called Koeneng, and Sibabat. The variety Sibabat which produces fruit with dark red or blackish color bears more pointed, thickly-set protuberances. The flesh separates easily from the seed. It is considered as the best variety of *N. mutabile* in Java. A form of Sibabat is called Sibabat Besar.

Planting materials and method of shipment. All of the nephelium planting materials which were introduced by the Department of Agronomy before 1924 were in the form of seed.

Planting materials introduced by the author were collected by him in Buitenzorg and Pasar Mingoe, Java, and consisted both of seed and of a living budded plant of *N. mutabile.* The seeds were buried in powdered charcoal and either placed in tins or wrapped in paper and sent to the Philippines by mail. The budded plant was transported in a wardian case.

Species and varieties introduced. Table 2 gives the Department of Agronomy accession numbers, dates of introduction, and the names of the varieties of *Nephelium* introduced by the College. It may be seen in table 2 that the first introduction was received on November 14, 1912, and it included both *N. mutabile* and *N. lappaceum.*

Planting introduced materials at high elevation on Mt. Maquiling. With the exception of materials bearing accession number 18103, 18592, and 18596, records show that all the nepheliums from Java were planted in a small clearing on the College of Agriculture concession on Mt. Maquiling presumably after passing through nursery cultures in the Agronomy Nursery. The elevation of the place is approximately 350 meters. It is probable that this location was chosen because *N. mutabile* is grown commercially in Java at elevations of 110 to 350 meters. The clearing was not fully exposed to the sun and it became more and more shaded until the nephelium plants became a portion of the surrounding forest. At

this place the total yearly rainfall and its distribution are about the same as on the College Campus.

The rambutan planted on Mt. Maquiling had accession numbers 1012, 1013, 1354, 1484, 1485, 1486, 1502, 1503, 1504, 1505, 1591, 2548, 2549, 2550, 2551, and 2552. The kapulasan had numbers 667, 1501, and 1590. All were planted in one straight row in the following order: 1501, 1502, 1503, 1504, 1505, 1590, 1591, 667, 1484, 1485, 1486, 2518, 1354, 2548, 2549, 2550, 2551, 2552, 1012, 1013. In the first inspection made of the planting it was found that Nos. 1012, 1351, and 1591 had died.

Planting at lower elevations. Introductions 18103, 18592, 18593, and 18596 were all grown at lower elevations, on the Faculty Hill, at an elevation of about 80 meters, and in the College Orchard, at an elevation of 50 meters.

Of the introductions listed above, those numbered 18103 and 1853 were rambutan. The seeds were first sown in seed boxes and subsequently potted. Seedlings of 18103 were kept in pots for two years and then transplanted, some in the College Orchard and two, on Faculty Hill.

Of the kapulasan, nearly all of the seedlings from seeds of introductions 18592 and 18596 were transplanted in the orchard practically in the open. By October, 1934, only six plants were surviving, likely because of unfavorable environmental conditions, a not too well-drained soil and too much exposure to sun and strong winds. These six plants were balled and transferred to a yard on Faculty Hill. Seven other kapulasan seedlings were planted on Faculty Hill.

From fruits produced by plants grown from introduced seeds, another generation of plants were grown some of which were planted on the Campus and some distributed to outside planters. Among the latter were fifty seedlings given to the Bureau of Plant Industry.

A budded Sibabat kapulasan, which was about 0.5 meter in height when it was introduced by the writer on August 27, 1927, was planted on Faculty Hill. When this fruited, the seeds were planted to produce seedlings for new plantings and to serve as stocks for inarching of scions from the same plant.

Vegetative propagation

Attempts were made to propagate asexually the nephelium plants used in this work in order (*a*) to make possible the estab-

lishment in the College Orchard of a duplicate set of the rambutan planted on Mt. Maquiling, (*b*) to multiply and distribute vegetative planting materials of such introduced plants as have fruited, and (*c*) to test the adaptability to nepheliums of the more common and easy methods of vegetative plant propagation.

Very little has been published in the Philippines about vegetative propagation of nepheliums. Wester (1920), in budding rambutan, impliedly advised using non-petioled, brown-gray, mature budwood, and cutting the bud 4 to 4.5 centimeters long. He remarked that the age of stock at the point of insertion was unimportant. Padolina (1931) advised, in grafting rambutan on bulala, to use non-petioled bud-stick, greenish to light brown in color, to cut it in a wedge shape from 10 to 12 centimeters long, and to insert it in a properly cut stock of about the same size, color, and age. He also stated that the time needed before a successfully marcotted rambutan branch could be separated from the mother tree was from three to eight months. Rambutan therefore had been successfully marcotted in the Philippines before the marcotting work reported in this work was started. In Java marcotting is the common method used by the nephelium growers.

Marcotting. For lack of previous experience in propagation of nepheliums by marcotting, it was decided to first carry on marcotting trials with trees in the orchard and on the Faculty Hill before attempting the same work on the less easily accessible trees on Mt. Maquiling. For this purpose about 40 branches were marcotted in January, 1934, by the late Mr. Ambrosio San Pedro of the Department of Agronomy on the orchard rambutan trees, and six on the female rambutan plant on the Faculty Hill by the writer in May, 1934. Fiber of cabo negro palm (*Arenga pinnata* [Wurmb] Merr.) was used for wrapping the soil utilized as rooting medium.

After successfully marcotting the rambutan plants at lower elevations, the trees at higher elevations on Mt. Maquiling were marcotted. As many of these trees are very tall, some of them had to be cut first to force them to produce low branches which were more convenient to handle. The marcotting operations were done on January 13, 14, 15, and 18, 1937.

Six branches of the female budded plant of *N. mutabile* on the Faculty Hill were also marcotted in May, 1934. Marcotting was repeated on March 28, 1939, both on the same budded plant and on a female seedling which had been fruiting since 1938.

Cuttage. More than 250 cuttings from 1.0 to 2.5 centimeters in diameter were obtained from a rambutan tree on Mt. Maquiling and planted in soil contained in an ordinary propagation box. The cuttings were given ordinary nursery care.

Inarching. Two fruiting kapulasan plants growing on Faculty Hill, one budded and the other a seedling, were used as sources of scions. For stocks, rambutan and kapulasan seedlings were used. The rambutan seedlings were raised from seeds of fruits gathered from a fruiting plant in the College Orchard, while the kapulasan seedlings were offspring of the budded plant shown in plate 2.

The inarching work in which rambutan seedlings were used as stocks was done by Dr. L. G. Gonzalez on December 28, 1935. There were six inarches made.

The inarching in which kapulasan seedlings were used as stocks was performed by Dr. Eulalio P. Baltazar and by the author with the help of Mr. Toribio Mercado. It was done partly on January 11, 1937, and partly at about the end of the summer of 1939. Ten branches were inarched in 1937, and 12 in 1939.

RESULTS AND DISCUSSION

Viability of seed in transit. Table 3 gives a record of the planting and germination of some of the introduced nephelium seeds. The results of the planting of seeds of *N. mutabile* show that seeds shipped either in cans or in a paper package may remain viable for at least 20 days and give a percentage of germination of about 64 per cent.

Growth. At the age of three months, rambutan seedlings were found to vary in height from 7.0 centimeters to 32 centimeters, and to average 18.5 centimeters. The frequency distribution in height of 47 seedlings at this age is given in table 4.

Table 5 shows the height and trunk diameter of rambutan trees about 22.5 years old which had been grown almost under forest condition, and table 6 the height and trunk diameter of rambutan plants grown in the orchard and on Faculty Hill.

The 22.5-year old trees averaged 10.9 meters in height and 10.1 centimeters in trunk diameter. Judging from the growth of rambutan trees in the orchard and on Faculty Hill, the trees on Mt. Maquiling had trunks too small for their height, because they had been growing under heavy shade. When the average height of the trees in the orchard was only about 2.6 meters, their average trunk

diameter was already more than 6.8 centimeters. Furthermore, the two trees on Faculty Hill which received better care than those in the orchard had larger diameters at the age of 10 years and 10 months than those on the mountain although they were shorter by about 3 meters. On July 26, 1940, when these two plants were 13 years old, the female had reached a height of 7.6 meters, a trunk diameter of 30 centimeters, and a crown spread of 8.8 meters. The male plant had been pruned constantly but it had a trunk diameter of 17.8 centimeters and a crown spread of 5.8 meters.

Table 7 gives some data on the growth of young plants whereas table 8 of much older ones. The seedlings averaged 17.1 centimeters in height at the age of 4.5 months, and 21.4 centimeters at the age of 10 months at 7 days.

As in the case of rambutan, it was observed (table 8) that the kapulasan planted in the orchard where they were more exposed to the sun grew less than those planted on Faculty Hill where they were less exposed. At the age of seven years, they had grown to a height of only about 0.5 meter and attained a maximum trunk diameter of 2.3 centimeters.

One of the kapulasan seedlings on Faculty Hill listed in table 8 was 4.7 meters high on July 24, 1924, when it was about 13 years old and had a trunk diameter of 12.0 centimeters and a crown spread of 4.5 meters (plate 1). Tree No. 7 in table 8, a male plant at the same age, was 5.8 meters high, had a trunk diameter of 14 centimeters and a crown spread of 5.8 meters. It should be remarked, however, that this particular plant is growing against a pummelo plant. It had undersized crown and was rather lanky, a fact that can be attributed most likely to too much shading from the pummelo and a star apple plant growing near it. One of the kapulasan plants has grown so slowly that at the age of 13 years, it was only 3.0 meters high, with a trunk diameter of only 7.6 centimeters and a crown spread of only 2.4 meters.

The budded kapulasan which was about 0.5 meter high on August 27, 1927, had reached a height of 3.3 meters on October 26, 1934, and attained a trunk diameter of 11 centimeters. On July 24, 1940, when it was already about 14 years old, it was 4.3 meters high and had a trunk diameter of 13.2 centimeters and a crown spread of 5.3 meters.

Flowering. One of the two rambutan plants grown from seeds introduced in January, 1924, and planted on Faculty Hill flowered for the first time in February, 1932, at the age of about eight years,

and the other at about the same month in 1934, at the age of ten years.

Regarding kapulasan, one of the seven plants raised from seeds introduced in February, 1927, first flowered in May, 1932, at the age of about five years. One seedling did not flower until the age of ten years. The budded plant flowered for the first time in May, 1934, at the age of eight years.

Manas, de los Reyes, and Godoy (1939) reported that in nephelium cultures of the Bureau of Plant Industry, rambutan first fruited in five to six years and bulala (kapulasan) in six to seven years. These figures may be taken as the approximate ages of flowering found in these species.

The flowering season of rambutan was found to be different from that of kapulasan. On Faculty Hill the rambutan flowering season occurs around January or February while that of kapulasan, about three months later, in April or May.

Fruiting. It has been observed in plants grown on Faculty Hill that the harvesting season of both rambutan and kapulasan occurs about four months after the flowering season. For rambutan, the season is in April or May and sometimes up to June and for kapulasan, August or September and sometimes as late as October. Manas, de los Reyes, and Godoy (1939) reported a fruiting season of June to October for rambutan and May to July for bulala (kapulasan). These seasons are presumably for Lamao, Bataan. They are somewhat different from those reported in this work.

Yield. The first harvest of rambutan from the first tree that fruited on Faculty Hill was 40 fruits. In 1938, only one fruit was produced. In 1939, about 40 were gathered, and 47 in 1940. In the College Orchard, the first harvest from a tree was 65 fruits, very few the second year, and 16 fruits the third year.

The kapulasan seedling plant on Faculty Hill gave only three fruits the first fruiting year, about 25 the second year, and 120 the third year. In 1939, it produced no less than 162 fruits but in 1940, only 44 (plate 1). The budded kapulasan (plates 2 and 3) produced a little more than 100 fruits the first year, more in the second year and less in the third. In 1939, it produced no less than 325 fruits but only 66 in 1940.

Regarding the culture on Mt. Maquiling, all the kapulasan plants must have died subsequently as no trace of any of them could be found in October, 1934. Kapulasan plants, being smaller than the

rambutan, those on the mountain must have been smothered by the taller neighboring nepheliums and forest trees. The results obtained from plantings on Mt. Maquiling have proved the inadvisability of cultures on the mountain without adequate and proper care. Such cultures are quite expensive to maintain and when not properly looked after they get shaded by forest plants, their fruiting is delayed, and a close watch on the plants would be necessary to prevent loss of fruit.

According to Ochse (1926), the Java rambutan plant yields from a minimum of five bunches to a maximum of 500 bunches of

Fig. 1.—(a) A parthenocarpic fruit of budded *Nephelium mutabile.* (b) A cross section of fruit shown in (a). (Drawn by Mr. M. S. Villaluz).

fruit, or an average of 50 to 137 bunches. A bunch may contain an average of 15 to 25 fruits. No data could be found on the yield of kapulasan.

The fruit and its value. The fruits of budded kapulasan (plates 2 and 3 and figures 1 and 2) averaged 70 grams in weight; 49 grams for the pod, 17.5 grams for the flesh, and 3.5 grams for the seed. They vary from 36 to 65 millimeters in length, averaging 54 millimeters, and from 36 to 60 millimeters in diameter, averaging 50 millimeters. The fruit of the seedling plant are somewhat smaller than those of the budded. However, the fruits of both trees are of commercial quality and are superior to those of the alupag (*Euphoria didyma* Blanco) and alupag kalabao (*Litchi philippinensis* Radlk.) of the Philippines and, as has been reported previously (Mendiola, 1937),[2] to the Chinese litchi fruit sold in Manila gro-

[2] Mendiola, N. B. 1937. Our forestry service and agriculture. Agricultural and Industrial Monthly 4: (No. 7) 3 and 15.

ceries. The flesh, or pulp, which is the edible portion, is quite thick and separates easily both from the skin and seed. They should sell for more than the imported litchi fruits.

The food value of nephelium fruit produced in the Philippines has not been determined. That of Java rambutan and kapulasan has been determined by Dr. Boorsma (Ochse, 1924). The edible-

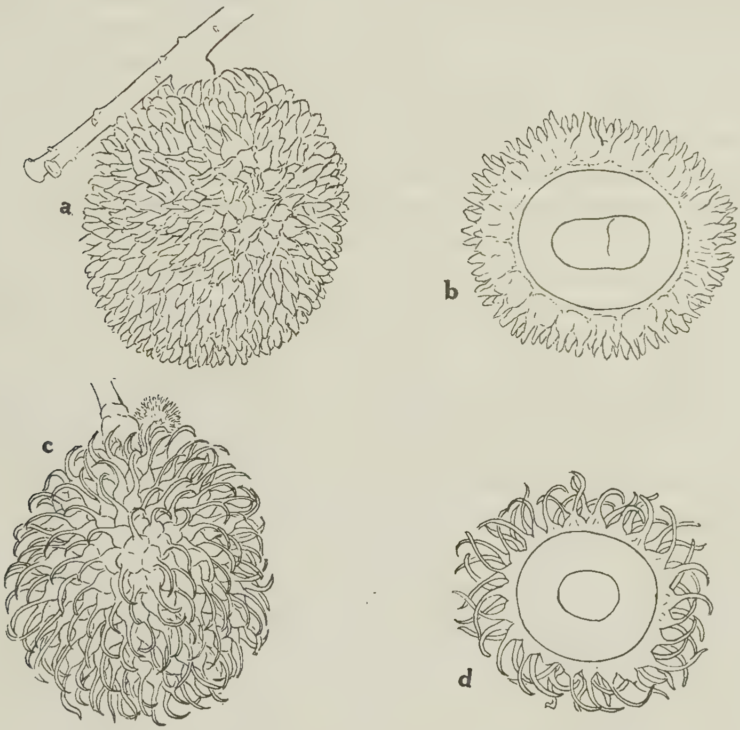

Fig. 2.—Fruits of *Nephelium mutabile* and *Nephelium lappaceum*. (a) A fruit of *N. mutabile* plant shown in plate 2. (b) A cross section of a *N. mutabile* fruit shown in figure 2a. (c) A fruit of *N. lappaceum*. (d) A cross section of a fruit of *N. lappaceum* shown in figure 2c. (Drawn by Mr. M. S. Villaluz).

fat content of the seeds of rambutan and kapulasan is reported by Heyne (1927) and by Georgi (1922).

Sex and parthenocarpy. One of the two rambutan plants growing on Faculty Hill turned out to be female whereas the other, male. The female plant produces mostly pistillate flowers and some hermaphroditic ones. In spite of the fact that since 1934 they have been flowering at the same time, some of the fruit produced by the female

tree were parthenocarpic. The same may be said of the kapulasan (figures 1 and 2). In both species, the parthenocarpic fruits can be distinguished easily from the normal seeded ones as the former are flat and the normal ones are rounded. While the parthenocarpic fruit has about the same thickness of pulp as the seeded ones, it is nevertheless not as desirable as the seeded ones, because they look smaller, they have aborted seeds which are apt to be eaten with the flesh, and would naturally command a lower price. For these reasons, it would be necessary to have a male tree in an isolated orchard of nepheliums.

Variability of nephelium plants. The advantages of asexual propagation of rambutan and kapulasan plants is so well recognized in Java that propagation by seed is not resorted to except to provide plants for use as stocks and for the production of new varieties or types. The practice of asexual propagation arose from the common observation that plants arising from seeds are very variable and may produce inferior fruit.

The author has in this work obtained evidence of the existence of this variability. For example, the rambutan plant growing on Faculty Hill is giving inferior, subacid to sour fruit, large seeded and with the pulp separating with difficulty from the seed. That in the College Orchard is only a little better. But both came from one of the best varieties of rambutan in Java. The seedling kapulasan which has been fruiting in the same year, while producing fruit of the same quality as those of the parent, gives somewhat smaller fruits and much darker in color, than those of the parent variety.

Even among very young plants, variability in certain characters are very noticeable. For example, whereas some are monoembryonic, the rest have from two to five embryos. Again, a study of 44 seedlings of kapulasan about one month old, showed that eight had greenish stems and leaves, 25 had purplish stems and leaves and 11, greenish purple.

Results of experiments on asexual propagation

Marcotting. Of the 40 branches of rambutan plants in the College Orchard marcotted in January, 1934, none had rooted up to October of the same year. On February 1, 1935, five marcots had already rooted.

The marcots on a female rambutan on Faculty Hill on May, 1934, were well rooted in September and were severed from the mother plant and potted in October, 1934. At the time of potting they varied in height from 1.5 to 3.1 meters, and in diameter of stem, 1.7 to 4.0 centimeters. Soon after potting, one died. This one was the largest, being 3.1 meters high and 4.0 centimeters in diameter. In Java smaller branches of rambutan are preferred for marcotting to larger ones, hence the result reported in this paper is not surprising.

Six years after separation from the mother plant, one of the successful marcots had grown to a height of about 4 meters and had a stem diameter of 7.5 centimeters and a crown spread of 2.7 meters. It had already flowered but had not fruited (plate 4). Another had reached a height of 4.02 meters, and had a stem diameter of 7.6 centimeters and a crown spread of about 3.0 meters.

The marcotting of rambutan plants on Mt. Maquiling was performed on January 13, 14, 15, and 18, 1937. On May 11 of the same year, the marcots were inspected and found to have begun producing roots. On July 12, marcots with roots were cut and brought down from the mountain and kept under shade for about a year. On September 10, 1938, four of the marcots were turned over to the Pomology Division of the Department of Agronomy for permanent planting in the College Orchard. They were given accession number 19868.

Of kapulasan, six marcots were performed in May, 1934, and ten marcots on March 28, 1939. Two of the marcots of May, 1934, had already produced a small number of roots by October 25 of the same year but not sufficient to make severance from the mother plant advisable. Finally these two were separated from the mother plant and planted in pots. However, during a storm, they were shaken badly and died. The rest of the marcots died even before they were separated from the mother plant.

The kapulasan marcotting performed on Faculty Hill on March 28, 1939, was more successful than those done previously. All marcots rooted and they were severed on December 23, 1939, and on January 13 and February 4, 1940. They were transplanted in an open orchard bordering a coconut plantation and started to make good growth but due to the severe dry months which prevailed in 1940, all except one, died. This was transferred to another location and subsequently died also.

Cuttage. None of the 250 cuttings tried rooted although the buds in some of them developed into shoots, which, however, died subsequently.

Inarching. On March 4, 1936, the scions of the inarchings made on December 28, 1935, and in which rambutan was used as stock were separated from the mother plant. Dr. L. G. Gonzalez submitted the following report on the results of this inarching: Out of the six plants, "two wilted and died soon after cutting, suggesting incomplete union; two suffered during the process of inarching; and two were successfully inarched. They grew well in pots for over a year. Of these, one was planted in the orchard. This died six months later, attacked by a beetle (*Euclea albata* Newm.), according to Dr. S. M. Cendaña. The other was planted in my [Dr. L. G. Gonzalez'] yard and is still living. When about a meter high, the main stem was attacked by the same kind of beetle, a few centimeters above the point of union. The upper portion of the plant wilted but that part of the scion which was left, grew. It has three shoots now about a foot high each."

The inarchings in which kapulasan seedlings served as stocks for kapulasan scion were separated in one-half to one year after the operation. Nearly 100 per cent success was obtained. All inarches had been transplanted and as far as the author knows, all are now growing except two, one of which succumbed to too much exposure to heat and sun and the other to lack of water during the last dry months. Two plants fruited two years after they had been transplanted.

Possible effects of the results of this work on the cultivation of nepheliums in the Philippines

It is hoped that the results of the work reported in this paper will go a long way towards the establishment of rambutan and kapulasan as regular cultivated fruits in the Philippines. Most of those interested in fruit growing and have seen and tasted the fruit of the kapulasan on Faculty Hill liked it very much and preferred it to the litchi. They secured planting materials when these were available or expressed a desire to secure them when they were not. Through these fruit enthusiasts, kapulasan plants produced in the College have reached Bataan, Cavite, Davao, La Union, Pampanga, Tarlac, and Tayabas. The results have encouraged further introduction of other Java varieties of nepheliums and a search for desirable varieties among those growing wild in the Philippines.

The successful introduction of and favorable results obtained with Java kapulasan should serve as a very definite encouragement for the government to complete the work already started in establishing nepheliums as regular cultivated fruit trees in the Philippines.

SUMMARY

1. Rambutan, *Nephelium mutabile*, and kapulasan, *N. lappaceum*, have been introduced successfully by seed from Buitenzorg, Java, and rambutan by a budded plant also from Pasar Mingoe Station of the same country.

2. Under local climatic conditions, rambutan plants seem to grow better than kapulasan in the open. Kapulasan plants need some shade and some irrigation during the dry season.

3. Some rambutan plants raised from seed fruited at the age of about 10 years whereas kapulasan, at about the age of seven years. A kapulasan plant of the variety Sibabat from Java budded on another plant of the same species first flowered and fruited on Faculty Hill, at the age of about eight years at an elevation of approximately 80 meters.

4. A seedling plant of introduced rambutan and two kapulasan have turned out to be male trees.

5. Introduced rambutan and kapulasan plants have been successfully marcotted and kapulasan successfully inarched on kapulasan stocks in the College of Agriculture. Kapulasan inarched on six rambutan stocks united but, with one exception, subsequently died after separation of the scions from the mother plant.

6. Rambutan and kapulasan on Faculty Hill have produced parthenocarpic fruits.

7. On the College Farm the flowering and fruiting seasons of the introduced nepheliums do not coincide. The rambutan flowers and fruits about three months earlier than the kapulasan, the fruiting season of rambutan coming in April and May and of kapulasan around August to October.

8. As a result of introduction work, seedling and inarched kapulasan plants are now being tried by private growers in several provinces of the Philippines, and further introduction of Java nepheliums and a search for superior varieties in Philippine forests have been encouraged.

LITERATURE CITED

BACKER, C. A. 1907. Flora van Batavia. Deel 1. Mededeelingen uitgaande van het Department van Landbouw. No. 4: Batavia: G. Kolff & Co.

GEORGI, C. D. V. 1922. Some Malayan vegetable oils and fats of minor importance. Malayan Agric. Jour. **10**: 222–227.

HEYNE, K. 1927. De nuttige planten van Nederlandsch Indie 2: 997-999. 2e Druk. Department van Landbouw, Nijverheid en Handel.

MANAS Y CRUZ, M., FERNANDO DE LOS REYES AND GREGORIO GODOY. 1939. Plant exploration and introduction work of the Bureau of Plant Industry. Philippine Jour. Agric. **10**: 249–270.

MERRILL, ELMER D. 1923. An enumeration of Philippine flowering plants. vol. 2. 530 p. Manila: Bureau of Printing.

OCHSE, J. J. 1924. Algemeene Vruchtenteelt. Drukkerij Volkslectuur, Weltevreden. ii + 159 blz. Met 93 teekeningen en 7 fotos.

OCHSE, J. J. 1926. De Vruchtencultuur in de Ommelanden van Batavia. Overgedrukt uit "Landbouw" 2 (No. 12): 923–1003.

OCHSE, J. J. 1927. Indische Vruchten. Volkslectuur, Weltevreden, Java. viii + 330 blz. met 141 teekeningen.

PADOLINA, FELIPE. 1931. Vegetative propagation experiments and seed germination. Philippine Jour. Agric. 2: 347–356.

WESTER, P. J. 1920. Plant propagation and fruit culture in the tropics. Philippines Bur. Agric. Bull. 32 (Second revised edition): 74.

EXPLANATION OF PLATES

PLATE 1

A seedling *Nephelium mutabile* plant grown from seed from Java, at the age of 13 years. It is 4.7 meters high and has a trunk diameter of 12 centimeters and a crown spread of 4.5 meters. It began fruiting at the age of 10 years. (Photograph by the Photographic Division, College of Agriculture).

PLATE 2

A budded plant of *Nephelium mutabile*, var. *Sibabat* from Java, first fruiting, at the age of eight years. (Photograph by the Photographic Division, College of Agriculture).

PLATE 3

A closer view of some fruiting branches of the *Nephelium mutabile* plant shown in plate 2. (Photograph by the Photographic Division, College of Agriculture).

PLATE 4

A marcotted *Nephelium lappaceum* plant as it appeared six years after it was severed from the mother plant. It is about 4 meters high and has a stem diameter of 7.5 centimeters and a crown spread of 2.7 meters. It has already flowered but has not yet fruited. (Photograph by the Photographic Division, College of Agriculture).

PLATE 1

PLATE 2

PLATE 3

PLATE 4

TABLE I

Rainfall in the Nephelium district around Batavia and at the College of Agriculture at Los Baños

COUNTRY	JAVA		PHILIPPINES
Station	Mr. Cornelis	Pasar Mingoe	College of Agriculture
Elevation above sea level	20 meters	35 meters	40 meters
Period covered	1879-1922	average [a]	1924-1932 average [b]
Month	*mm*	*mm*	*mm*
January	326	323	63.4
February	322	286	28.9
March	208	266	19.9
April	151	196	49.5
May	116	162	147.7
June	100	117	167.2
July	71	84	327.0
August	49	63	248.4
September	85	113	253.0
October	132	171	290.0
November	174	246	272.7
December	208	246	160.5
Total	1942	2273	2028.2

[a] From OCHSE, J. J. 1927. De Vruchtencultuur in de Ommelanden van Batavia. Overgedrukt uit "Landbouw" 2 (12): 923-1003.

[b] From ESTIOKO, ROMAN P. 1939. Weather observations at the College of Agriculture, 1924-1937. The Philippine Agriculturist 28: 206-224.

TABLE 2

Nepheliums introduced from Java

ACCESSION NUMBER	VARIETY NAME	SPECIES	DATE OF INTRODUCTION
677	Item Sibabat	*N. mutabile*	November 14, 1912
1012		*N. lappaceum*	January 20, 1913
1013		*N. lappaceum*	January 20, 1913
1351	Tjengkeh [a]	*N. lappaceum*	January 29, 1913
1354		*N. lappaceum*	January 29, 1913
1484	Atjeh Matjan	*N. lappaceum*	March 1, 1913
1485	Tangkoeweh	*N. lappaceum*	March 1, 1913
1485	var. Atjeh Goela Boeloe	*N. lappaceum*	March 1, 1913
1486	Atjeh Goela Boeloe	*N. lappaceum*	March 1, 1913
1501	Sibabat Besar	*N. mutabile*	March 13, 1913
1502	Atjeh Matjan	*N. lappaceum*	March 1, 1913
1503	Atjeh Matjan Besar	*N. lappaceum*	March 1, 1913
1504	Atjeh Goela Boele	*N. lappaceum*	March 1, 1913
1505	Atjeh Lebak Boeloes	*N. lappaceum*	March 1, 1913
1590	Sibabat Besar	*N. mutabile*	April 16, 1913
1591	Merah	*N. mutabile*	April 16, 1913
2335		*N. lappaceum*	November 25, 1913
2518	Merah	*N. mutabile*	January 7, 1914
2548	Atjeh Matjan Besar	*N. lappaceum*	January 22, 1914
2549	Atjeh Lebak Boeloes	*N. lappaceum*	January 22, 1914
2550	Atjeh Konto	*N. lappaceum*	January 22, 1914
2551	Sibabat	*N. mutabile*	January 22, 1914
2552	Matjan Besar	*N. mutabile*	January 22, 1914
18103		*N. lappaceum*	January 24, 1924
18592		*N. mutabile*	February 2, 1927
18593		*N. lappaceum*	February 2, 1927
18596	Sibabat	*N. mutabile*	February 16, 1927
	Sibabat	*N. mutabile*	August 27, 1927
19985		*N. lappaceum*	May 29, 1939
19986	Simatjan	*N. lappaceum*	May 29, 1939
19987	Sitangkoeweh	*N. lappaceum*	May 29, 1939
19988	Sinjonja	*N. lappaceum*	May 29, 1939
19989	Lebak Boeloes	*N. lappaceum*	May 29, 1939
19990	Sibabat	*N. mutabile*	May 29, 1939
19991	Extra	*N. mutabile*	May 29, 1939

[a] This name does not appear in list of names of rambutan varieties of Java. It is probably a misspelling of "Tangkoeweh".

TABLE 3

Record of sowing and germination of introduced Nephelium seeds

ACCESSION NUMBER	SPECIES	NO. OF SEEDS RECEIVED	DATE RECEIVED	DATE PLANTED	DATE GERMINATED	NO. OF SEEDLINGS PRODUCED	REMARKS
			1927	*1927*	*1927*		
C.N. 18592	*N. mutabile*	50	February 2	February 2	February 16	32	Mailed in Java, January 12, 1927. From one tree at 84 Bondongan, Buitenzorg.
C.N. 18596	*N. mutabile*	39	February 16	February 16	February 26	25	Mailed in Java, February 2, 1927.
C.N. 18593	*N. lappaceum*	(Received in bad condition) 40	February 2	February 2	—	None	Did not germinate. Mailed in Java January 12, 1927.

TABLE 4

Frequency distribution in height of 3-month old rambutan seedlings

CLASS RANGE	FREQUENCY
centimeters	
5.1 — 7	1
7.1 — 9	2
9.1 — 11	1
11.1 — 13	5
13.1 — 15	3
15.1 — 17	7
17.1 — 19	10
19.1 — 21	7
21.1 — 23	4
23.1 — 25	1
25.1 — 27	2
27.1 — 29	3
29.1 — 31	0
31.1 — 33	1
Total	47
Average	18.1 centimeters

TABLE 5

Variation in height and greatest trunk diameter of 22½-year old rambutan trees on Mt. Maquiling

HEIGHT		TRUNK DIAMETER	
Class value	Frequency	Class value	Frequency
meters		*centimeters*	
1.5	5	1.5	2
3.5	5	3.5	13
5.5	16	5.5	24
7.5	19	7.5	16
9.5	15	9.5	12
11.5	13	11.5	18
13.5	15	13.5	15
15.5	25	15.5	11
17.5	7	17.5	8
19.5	5	19.5	3
		21.5	2
		23.5	0
		25.5	1
Total	125 trees		125 trees
Average	10.9 meters		10.1 centimters

TABLE 6

Height and trunk diameter of rambutan plants about 10 years and 10 months old

TREE NO.	HEIGHT	GREATEST DIAMETER OF STEM	WHERE GROWN
	meters	*centimeters*	
1	3.8	22.0	In orchard, Experiment Station
2	4.6	15.2	" " " "
3	0.7	0.5	" " " "
4	2.5	3.5	" " " "
5	2.5	4.8	" " " "
6	2.7	3.8	" " " "
7	3.2	6.3	" " " "
8	2.6	4.5	" " " "
9	0.4	0.9	" " " "
10	7.4	12.3	In yard on Faculty Hill
11	8.0	18.5	" " " " "

TABLE 7

Frequency distribution in height of kapulasan seedlings

AGE	4.5 MONTHS	10 MONTHS AND 7 DAYS
Class range	Frequency	Frequency
centimeters		
7.1–9	1	0
9.1–11	1	3
11.1–13	2	4
13.1–15	8	4
15.1–17	20	7
17.1–19	11	11
19.1–21	5	8
21.1–23	3	7
23.1–25	1	7
25.1–27	1	10
27.1–29	1	6
29.1–31	0	5
31.1–33	0	3
33.1–35	0	1
Total	54	76
Average	17.1 centimeters	21.4 centimeters

TABLE 8

Height and stem diameter of kapulasan plants about seven years old

PLANT NO.	HEIGHT	GREATEST DIAMETER OF STEM	WHERE GROWN
	meters	*centimeters*	
1	0.6	Very small	In orchard at Experiment Station
2	0.7	Very small	" " " " "
3	0.4	Very small	" " " " "
4	1.3	2.3	" " " " "
5	main stem died, replaced by small shoot		" " " " "
6	2.3	1.5	" " " " "
7	4.5	7.7	In a yard on Faculty Hill
8	4.0	8.3	" " " " " "
9	2.0	4.3	" " " " " "
10	2.5	5.1	" " " " " "
11	2.5	6.1	" " " " " "
12	2.3	4.5	" " " " " "

COMPARATIVE MINERAL CONSTITUENTS (IRON, CALCIUM, AND PHOSPHORUS) OF ELON-ELON RICE GROWN IN DIFFERENT PARTS OF THE PHILIPPINES [1]

Hipolito A. Custodia

That environment exerts an important influence on the composition of cereals has been proven in wheat. It was thought worthwhile to follow up this finding and determine whether rice is similarly influenced. Velasco (1940) made proximate analysis of thirty samples of the Elon-elon variety of rice from different regions of the Philippines. The result of his investigation seemed to show that the mean protein content of rice from the regions where there is uniform rainfall was significantly higher than that of the samples from the distinct dry and wet regions. It seems, probable, therefore, that the inorganic constituents of rice are likely to be similarly affected. For this reason Elon-elon rice from different regions of the Philippines was analyzed for iron, calcium, and phosphorus to determine the significance of the differences in these constituents, if any existed.

The effect of environment upon the composition of grain has been the subject of many investigations by numerous workers. Their results have been quite contradictory and have resulted in a very wide divergence of opinion as to the factors which influence the nature of crop.

According to Wiley (1901), when Richardson grew crops from seeds of the same kind and of known composition in different localities, it was found that the composition of the resulting crop differed from that of the original. Hence, he concluded that the soil was most important in producing these changes.

Shaw and Walters (1911) reported the statement of Schindler that "the composition of the grain depends upon the fertility of the soil." They also cited the conclusion of Cross and Smith (1895) that the condition of soil nutrition had little influence upon the composition of the plant. "The plant, in other words, is, as regards soil nutrition, constant or invariable in respect to the relation of its products to assimilation."

---

[1] Experiment Station contribution No. 1431. Prepared in the Department of Agricultural Chemistry under the direction of Professor F. O. Santos.

Shaw and Walters (1911) also showed that a chemical analysis of a soil reveals no definite relation between the chemical composition of the soil and the crop. They also cited Hall, who stated that "the soil is the least effective environmental factor in producing variations in the composition of wheat."

Le Clerc and Yoder (1914) showed that "the climatic factors collectively have a strong determining influence, especially upon the crude-protein content, ash content, and the percentage of phosphoric acid in the ash." They claimed that the climatic differences, such as humidity, rainfall, temperature, and sunlight, may bring about changes in the physical, chemical, or biological characteristics of the soil, which in turn may react on the crop.

Le Clerc and Leavitt (1910) concluded that "wheats of the same variety when grown in the same locality and under the same conditions are, therefore, seen to vary but little in composition, although coming from seeds differing widely in physical and chemical characteristics. Wheat of any one variety, from any one source, and absolutely alike in chemical and physical characteristics, when grown in different localities, possessing different climatic conditions, yields crops of very widely different appearance and very different in chemical composition."

Ames (1910) stated that "the absorption by a plant of an essential mineral element is a physiological process, and depends upon its vital activities, which may be affected by any of the conditions which influence crop growth and yields. The principal factors, therefore, which influence variation in composition of the wheat plant may be any one or a combination of the following conditions: favorable or unfavorable seasons, composition of the soil, fertilizers applied to the soil, soil moisture, and thickness of stand."

According to Wells, Agcaoili, and Feliciano (1922), Kelly and Thompson in 1910 showed that the chemical composition of rice kernels, as well as other parts, is greatly influenced by several factors; namely, seasonal variations, type of soil, and nature of fertilizer used. They claimed that "as the seasonal variation in this country is very slight throughout the year, its effect can be practically eliminated from consideration. This would seem, therefore, to suggest that the problem of improving the quality of rice resolves itself into a proper control of fertilizers, methods of cultivation, and irrigation."

Greaves and Nelson (1924) analyzed numerous samples of wheat, oats, and barley composited from several crops grown on

soil receiving different quantities of irrigation water. Their results showed that the iron and chlorine contents of wheat increased with the quantity of water applied during the growing season.

MATERIALS AND METHODS

Rice samples

Elon-elon, a widely distributed rice variety in the Philippines, was used in this study. Thirty samples of this variety gathered from widely distributed places of the Islands were analyzed by Velasco (1940) for the organic constituents. He also gave field information on these samples. The same materials were analyzed by the writer for the various inorganic constituents.

Preparation of samples

The rough grains were pounded in a porcelain mortar, and the hull was separated from the kernel by winnowing. The hulled grains were then powdered and later passed through a 40-mesh sieve. The fine-ground samples were kept in 250-ml. Erlenmeyer flasks and corked airtight. Great care was exercised to prevent insect attacks and growth of molds.

Methods of analyses

All analyses were in accordance with the A.O.A.C. methods (Anonymous, 1935) except that ash was determined by the hydrogen peroxide method of Sullivan and Near (1927). Calcium and phosphorus were determined volumetrically; and iron, colorimetrically.

RESULTS AND DISCUSSION

The results are presented in seven tables. All the analytical data were averages of four concordant determinations. Bessel's formula was used in the calculation of the probable error of the means. The samples were divided into two groups according to region of origin as suggested by Velasco (1940), in accordance with the "Climate of the Philippines" (Anonymous, 1939). The samples from regions of distinct dry and wet seasons composed the first group, and those from regions of uniform rainfall, the second group. The soil samples were obtained from the barrio where the corresponding grain sample was gathered; however, it was not known, whether both of them came from the same spot.

Calcium

Distinct dry and wet season. Calcium varied from 7.3 ± 0.51 to 19.4 ± 0.52, with an average of 11.3 ± 0.49 mgm. per 100 grams of water-free sample (table 1). The sample from Sibalom, Antique, had the highest; and that from Balayan, Batangas, the lowest. A significant difference occurred in the calcium content of these two samples. Of the five comparisons made, two differences were statistically insignificant; and three, significant (table 2).

The finding of Hall, as reported by Shaw and Walters (1911), that no strict agreement existed between the chemical composition of the soil and the oat plant pointed to the probability of a similar phenomena that may exist in rice. Thus, the calcium oxide contents of the soil and of the rice kernel were correlated (table 4). The table shows an insignificant correlation between the two components (r = –.4111). However, no definite conclusion could be drawn because of the meager data available. Yet, this result is in strict accord with the result of Hall (Shaw and Walters, 1911).

When the calcium contents of the samples under this group were correlated with Lang's rain factor (table 5), an insignificant correlation (r = + 0.4893) was likewise obtained.

Uniform rainfall. The amount of calcium in the samples ranged from 8.2 ± 0.19 to 14.2 ± 0.17, with an average of 10.1 ± 0.36 mgm. per 100 grams of oven-dry sample (table 1). The sample from Aparri, Cagayan, had the highest calcium content for this group; and that from Libertad, Butuan, Agusan, the lowest. When six samples were compared (table 3), four differences were very significant; but the difference between samples from Libertad, Butuan, Agusan (lowest) and San Vicente, Butuan, Agusan was insignificant. This could be expected because both samples came from the same place.

In order to ascertain whether the rainfall and temperature exerted influence upon the calcium of the rice kernel, correlations between Lang's rain factor and the rice calcium content were made (table 6). This table shows an insignificant correlation (r = –.1551). The same result was found in the first group; hence it can be tentatively concluded that the rainfall-temperature factor did not influence the calcium content of the rice during its period of growth.

Iron

Distinct dry and wet seasons. Of the seventeen samples in this group, the rice from Sibalom, Antique, had the highest iron content; and the sample from Tayug, Pangasinan, the lowest (table 1). The range was from 3.2 ± 0.05 to 8.5 ± 0.02, with an average of 5.3 ± 0.27 mgm. per 100 grams of oven-dry sample. The iron contents of six samples, including the highest and the lowest, were compared statistically (table 2). Significant differences were found except between samples from Tanay, Rizal and from Tayug, Pangasinan.

The results of Greaves and Nelson (1924) on the effect of the amount of irrigation water on plant composition showed that the iron contents of wheat increased with the quantity of water applied during the growing period. Because data on irrigation of the fields where the samples were grown were not available, the writer could not follow up this statement.

Has the rainfall-temperature factor any effect upon the iron content of the rice kernel? To answer this question, the writer correlated the iron content of the rice kernel with Lang's rain factor. Table 5 shows an insignificant correlation (r = + .1049).

Uniform climate. Table 1 shows that the sample from Aparri, Cagayan, had the highest iron content for the second group; and that from San Vicente and Butuan, Agusan, the lowest. The range was from 2.0 ± 0.01 to 6.4 ± 0.07, with an average of 4.0 ± 0.27 mgm. per 100 grams of oven-dry sample.

When the samples having highest and lowest iron content were compared together with four others (table 3), very significant differences occurred in all cases. This result shows a wide divergence of iron contents in the samples belonging to the second group.

As in the first group, an insignificant correlation existed between rainfall-temperature and the iron content of the samples (table 6). The same reason for the non-existence of a significant correlation between these two variables for the first group may hold true for this group.

Phosphorus

Distinct dry and wet season. The phosphorus content of the samples varied from 359.9 ± 3.06 to 583.5 ± 2.95, with an average of 471.4 ± 8.52 milligrams per 100 grams of oven-dry sample

(table 1). The sample that had the highest phosphorus content came from Hagonoy, Bulacan; and the lowest, from General Trias, Cavite. When these two limits together with four others were compared, very significant differences were found in all cases (table 2). This shows that there was a great variation in the phosphorus content of the samples belonging to the first group. This wide divergence in phosphorus content may be attributed to the influence of the environment. However, not enough data were available to warrant assigning this variation to any particular factor of the environment.

In order to verify the conclusion of Shaw and Walter (1911) that a chemical analysis of a soil reveals no definite relation between the chemical composition of the soil and that of the crop, data on the phosphorus pentoxide content of the soil from different localities were obtained from the published soil survey reports of the Soil Survey Division, Department of Agriculture and Commerce (Alicante *et al*, 1936, 1937, 1938, 1939, 1940). A correlation table was prepared (table 4), and the result showed insignificant correlation ($r = —.3610$) between the phosphorus pentoxide contents of the soil and of the rice kernel. This finding is in close accord with that of Shaw and Walters.

That humidity, rainfall, temperature, and sunlight have a strong influence upon the crude protein, ash, and phosphoric acid contents of wheat was hinted by Le Clerc and Yoder (1914). In order to find whether or not rice is similarly influenced, data on rainfall and temperature were gathered. Lang's rain factor, the ratio of mean rainfall to mean temperature, was correlated with the phosphorus content of the rice sample (table 5). An insignificant correlation ($r = + .2268$) existed between these two variables. This result tends to show that during the growth of the rice, the rainfall and temperature had a negligible effect upon the absorption of phosphorus from the soil.

Uniform rainfall. The amount of phosphorus in the rice samples comprising this group ranged from 390.3 ± 3.82 to 542.5 ± 5.77, with an average of 462.5 ± 7.10 mgm. per 100 grams of oven-dry sample (table 1). The sample from Ajuy, Iloilo had the highest phosphorus content; and that from Tiaong, Tayabas, the lowest. When the phosphorus contents of six samples including both the upper and lower limits were compared, two pairs had significant differences and three pairs, all insignificant. The sample from Tiaong,

Tayabas and that from Libertad, Butuan, Agusan had a significant difference in favor of the latter (table 3).

As regards the effect of rainfall and temperature upon the phosphorus content of the rice under this second group, no marked influence was observed. An insignificant correlation (r = + .6989) existed between Lang's rain factor and the phosphorus of the plant (table 6). This was also true in the first group.

Correlation between the mineral constituents

Distinct dry and wet season. By the use of data given in table 1, it was found that not a pair of the three elements, calcium, iron, and phosphorus, had a significant correlation. Between calcium and iron, however, the correlation (r = + .4252) tended to be significant. The other pairs such as calcium versus phosphorus, and phosphorus versus iron, had very insignificant correlation, *r* being + .1791 and + .3932, respectively.

Uniform rainfall. Contrary to the result in group 1, a slightly significant correlation (r = + .6248) existed between calcium and iron. In the first group, however, the calcium and iron were almost significantly correlated. Hence, it may be tentatively stated that a high amount of calcium was indicative of a proportionately high amount of iron.

The other pairs correlated, such as iron against phosphorus and calcium against phosphorus, showed statistically insignificant correlation (a = —.0706 and —.1199 respectively).

Analysis of data from the standpoint of rainfall

The effect of rainfall in the production of divergence in composition between the rice of the first group and that of the second may be seen in table 7.

No significant differences existed between calcium and phosphorus. However, with iron, a statistically significant difference occurred between these two groups in favor of the distinct dry and wet season group.

SUMMARY

1. Twenty-nine samples of Elon-elon rice gathered from various regions of the Philippines were analyzed for calcium, iron, and phosphorus.

2. Differences in amounts of constituents were found between rice samples from regions of distinct dry and wet seasons. Calcium

ranged from 7.3 ± 0.51 to 19.4 ± 0.52, with an average of 11.3 ± 0.49 mgm. per 100 grams oven-dry sample; iron, from 3.2 ± 0.05 to 8.5 ± 0.02, with an average of 5.3 ± 0.27 mgm.; and phosphorus, from 359.9 ± 3.06 to 583.5 ± 2.95, with an average of 471.4 ± 8.52 mgm.

3. The samples from regions of uniform rainfall likewise had variable composition. Calcium ranged from 8.2 ± 0.19 to 14.2 ± 0.17, with an average of 10.1 ± 0.36 mgm. per 100 grams oven-dry sample; iron, from 2.0 ± 0.01 to 6.4 ± 0.07, with an average of 4.0 ± 0.27 mgm., and phosphorus, from 390.3 ± 3.82 to 542.5 ± 5.77, with an average of 462.5 ± 7.10 mgm.

4. In the first group (distinct wet and dry seasons), the sample from Sibalom, Antique, contained the most calcium and iron; and that from Hagonoy, Bulacan, the most phosphorus. The sample containing the lowest calcium came from Balayan, Batangas; lowest iron, from Tayug, Pangasinan; and lowest phosphorus, from General Trias, Cavite.

5. Of the samples comprising the second group (uniform rainfall), the one from Aparri, Cagayan, had the highest calcium and iron contents, and that from Ajuy, Iloilo, the highest phosphorus. The samples from Butuan, Agusan contained the lowest amount of calcium and iron, and the sample from Tiaong, Tayabas, the lowest phosphorus.

6. A statistically insignificant correlation seemed to exist between calcium oxide and phosphorus contents of the soil and of the rice kernel.

7. No statistically significant correlation existed between the ratio of the mean yearly rainfall to the mean yearly temperature (Lang's rain factor) and the calcium, iron, or phosphorus contents of the samples in both groups.

8. The calcium and iron contents of the samples belonging to both groups showed a tendency to be significantly correlated; that is, a high amount of calcium may indicate a large amount of iron and vice versa.

9. In both groups, insignificant correlations existed between calcium and phosphorus and between phosphorus and iron in the rice kernel.

10. No statistically significant difference was found between the calcium and the phosphorus contents of the two groups.

11. The average iron content of rice from regions of distinct dry and wet season was significantly higher than that from regions of uniform rainfall.

LITERATURE CITED

ALICANTE, M. M., D. Z. ROSELL, R. ISIDRO, AND S. HERNANDEZ. 1936. Soil survey of Bulacan province, Philippine Islands. Dept. Agric. Comm. Tech. Bull. 5: 1–28.

ALICANTE, M. M., D. Z. ROSELL, R. ISIDRO, AND S. HERNANDEZ. 1937. Soil survey of Rizal province, Philippine Islands. Dept. Agric. Comm. Soil Report 2: 1–33.

ALICANTE, M. M., D. Z. ROSELL, AND S. HERNANDEZ. 1938. Soil survey of Batangas province, Philippine Islands. Dept. Agric. Comm. Soil Report 4: 1–36.

ALICANTE, M. M., D. Z. ROSELL, R. T. MARFORI, AND S. HERNANDEZ. 1939. Soil survey of Pampanga province, Philippines. Dept. Agric. Comm. Soil Report 5: 1–37.

ALICANTE, M. M., D. Z. ROSELL, R. T. MARFORI, AND S. HERNANDEZ. 1940. Soil survey of Tarlac province, Philippines. Dept. Agric. Comm. Soil Report 6: 1–36.

AMES, J. W. 1910. The composition of wheat. Ohio Agric. Exper. Sta. Bull. 221: 1–37.

ANON. 1935. Official and tentative methods of analysis of the Association of Official Agricultural Chemists, 4th. ed., xix + 691, p., 52 fig. Washington, D. C.: Assoc. Off. Agric. Chemists.

ANON. 1939. Climate of the Philippines. P. I. Dept. Agric. Comm. 31 p., 1 fig.

GREAVES, J. E., AND D. H. NELSON. 1924. The iron, chlorine, and sulfur content of grains and the influence of irrigation water upon them. Soil Science 19: 325–329.

LE CLERC, J. A., AND S. LEAVITT. 1910. Tri-local experiment on the influence of environment on the composition of wheat. U. S. Dept. Agric., Bur. Chem. Bull. 128: 1–18.

LE CLERC, J. A., AND P. A. YODER. 1914. Environmental influence on the physical and chemical characteristics of wheat. Jour. Agric. Res. 1: 275–291.

SHAW, G. W., AND E. H. WALTERS. 1911. A progress report upon soil and climatic factors influencing the composition of wheat. California Agric. Exper. Sta. Bull. 216: 1–23.

SULLIVAN, B., AND CLEO NEAR. 1927. The ash of hard-spring wheat and its products. Ind. Engin. Chem. (Anal. Ed.) **19**: 498–501.

VELASCO, JOSÉ. 1940. Studies on the nutritive value of the Elon-elon rice variety grown in different parts of the islands. The Philippine Agriculturist **29**: 238–252.

WELLS, A. H., F. AGCAOILI, AND R. T. FELICIANO. 1922. Philippine rice. Philippine Jour. Sci. **20**: 353–361.

WILEY, H. W. 1901. Influence of environment on the chemical composition of plants. U. S. Dept. Agric. Yearbook **1901**: 299–318.

TABLE 1

Mineral constituents of Elon-elon rice grown in different parts of the Philippines

ORIGIN OF SAMPLES	CALCIUM mgm. per 100 grams oven-dry sample	IRON mgm. per 100 grams oven-dry sample	PHOSPHORUS mgm. per 100 grams oven-dry sample
Distinct Dry and Wet:			
Agricultural College, Laguna	11.6 ± 0.15 [l]	5.8 ± 0.00	508.3 ± 3.41
Balayan, Batangas	7.3 ± 0.51	7.4 ± 0.02	451.9 ± 2.55
Batangas, Batangas	9.3 ± 0.04	4.9 ± 0.19	437.8 ± 3.71
Biñan, Laguna	12.0 ± 0.54	4.1 ± 0.01	486.8 ± 2.74
Central Luzon Agricultural School, Nueva Ecija	8.7 ± 0.02	4.0 ± 0.01	534.8 ± 4.56
General Trias, Cavite	10.4 ± 0.37	4.7 ± 0.00	359.9 ± 3.06 [l]
Hagonoy, Bulacan	14.0 ± 0.43	7.7 ± 0.20	583.5 ± 2.95 [h]
Malolos, Bulacan	10.3 ± 0.01	8.3 ± 0.06	504.0 ± 2.16
Quezon, Nueva Ecija	15.4 ± 0.29	5.4 ± 0.04	486.1 ± 3.47
San Isidro, Nueva Ecija	10.1 ± 0.39	3.5 ± 0.02	401.8 ± 2.62
San Marcelino, Zambales	8.4 ± 0.24	5.1 ± 0.10	510.0 ± 2.47
Santa Barbara, Pangasinan	14.5 ± 0.49	5.1 ± 0.05	488.1 ± 4.75
Sibalom, Antique	19.4 ± 0.52 [h]	8.5 ± 0.02 [h]	479.9 ± 5.03
Tanay, Rizal	10.9 ± 0.17	3.3 ± 0.06	443.1 ± 2.20
Tanza, Cavite	10.3 ± 0.40	4.5 ± 0.05	463.8 ± 4.19
Tarlac, Tarlac	10.8 ± 0.18	5.0 ± 0.12	446.1 ± 3.66
Tayug, Pangasinan	8.6 ± 0.12	3.2 ± 0.05 [l]	428.4 ± 0.97
Average	11.3 ± 0.49	5.3 ± 0.27	471.4 ± 8.52
Uniform rainfall:			
Aparri, Cagayan	14.2 ± 0.17 [h]	6.4 ± 0.07 [h]	472.8 ± 1.62
Ajuy, Iloilo	9.0 ± 0.14	4.3 ± 0.05	542.5 ± 5.77 [h]
Bayombong, Nueva Vizcaya	9.8 ± 0.11	3.0 ± 0.07	408.4 ± 3.71
Libertad, Butuan, Agusan	8.2 ± 0.19 [l]	3.7 ± 0.03	526.0 ± 1.18
Lumbatan, Lanao	12.5 ± 0.20	5.9 ± 0.15	476.3 ± 12.85

[l]—Lowest
[h]—Highest

TABLE 1—(Continued)

ORIGIN OF SAMPLES	CALCIUM mgm. per 100 grams oven-dry sample	IRON mgm. per 100 grams oven-dry sample	PHOSPHORUS mgm. per 100 grams oven-dry sample
Margosatubig, Zamboanga	11.3 ± 0.19	4.3 ± 0.16	398.9 ± 4.93
Naga, Camarines Sur	8.9 ± 0.16	2.8 ± 0.01	528.9 ± 1.14
Pagadian, Zamboanga	10.6 ± 0.36	3.9 ± 0.06	501.9 ± 0.81
Santiago, Isabela	8.4 ± 0.19	5.9 ± 0.06	395.2 ± 1.35
San Vicente, Butuan, Agusan	8.3 ± 0.10	2.0 ± 0.01 [l]	468.8 ± 5.37
Tiaong, Tayabas	10.1 ± 0.19	3.0 ± 0.08	390.3 ± 3.82 [l]
Ubay, Bohol	9.4 ± 0.20	3.0 ± 0.08	440.4 ± 1.28
Average	10.1 ± 0.36	4.0 ± 0.27	462.5 ± 7.10
General average	10.8 ± 0.33	4.8 ± 0.21	467.7 ± 6.61

[h]—Highest
[l]—Lowest

TABLE 2

Comparison between maximum and minimum constituents of rice grown in regions of distinct dry and wet seasons

ORIGIN OF SAMPLES	COMPARISONS	QUANTITY [a]	DIFFERENCE
Calcium:			
1. Sibalom, Antique (Maximum)		19.4 ± 0.52	
2. Balayan, Batangas (Minimum)	(1) : (2)	7.3 ± 0.51	12.1 ± 0.73 (S)
3. Santa Barbara, Pangasinan	(1) : (3)	14.5 ± 0.49	4.9 ± 0.71 (S)
4. San Marcelino, Zambales	(2) : (4)	8.4 ± 0.24	1.1 ± 0.56 (I)
5. Quezon, Nueva Ecija	(2) : (5)	15.4 ± 0.29	8.1 ± 0.59 (S)
6. Tayug, Pangasinan	(2) : (6)	8.6 ± 0.12	1.3 ± 0.52 (I)
Iron:			
1. Sibalom, Antique (Maximum)		8.5 ± 0.02	
2. Tayug, Pangasinan (Minimum)	(1) : (2)	3.2 ± 0.05	5.3 ± 0.05 (S)
3. Malolos, Bulacan	(1) : (3)	8.3 ± 0.06	0.2 ± 0.06 (S)
4. Tanay, Rizal	(2) : (4)	3.3 ± 0.06	0.1 ± 0.08 (I)
5. Hagonoy, Bulacan	(2) : (5)	7.7 ± 0.20	4.5 ± 0.21 (S)
6. San Isidro, Nueva Ecija	(2) : (6)	3.5 ± 0.02	0.3 ± 0.05 (S)
Phosphorus:			
1. Hagonoy, Bulacan (Maximum)		583.5 ± 2.95	
2. General Trias, Cavite (Minimum)	(1) : (2)	359.9 ± 3.06	223.6 ± 4.25 (S)
3. Central Luzon Agricultural School, Nueva Ecija	(1) : (3)	534.8 ± 4.56	48.7 ± 5.43 (S)
4. Tayug, Pangasinan	(2) : (4)	428.4 ± 0.97	68.5 ± 3.21 (S)
5. San Marcelino, Zambales	(2) : (5)	506.0 ± 2.47	146.1 ± 3.93 (S)
6. San Isidro, Nueva Ecija	(2) : (6)	401.8 ± 2.62	41.9 ± 4.02 (S)

[a] Calcium, iron, and phosphorus, in milligrams per 100 grams of oven-dry sample.
(I)—Insignificant
(S)—Significant

TABLE 3

Comparison between maximum and minimum constituents of rice grown in regions of uniform rainfall

ORIGIN OF SAMPLES	COMPARISONS	QUANTITY [a]	DIFFERENCE
Calcium:			
1. Aparri, Cagayan (Maximum)		14.2 ± 0.17	
2. Libertad, Butuan, Agusan (Minimum)	(1) : (2)	8.2 ± 0.19	6.0 ± 0.25 (S)
3. Lumbatan, Lanao	(1) : (3)	12.5 ± 0.20	1.7 ± 0.26 (S)
4. San Vicente, Butuan, Agusan	(2) : (4)	8.3 ± 0.10	0.1 ± 0.21 (I)
5. Margosatubig, Zamboanga	(2) : (5)	11.3 ± 0.19	3.1 ± 0.27 (S)
6. Santiago, Isabela	(2) : (6)	5.9 ± 0.06	2.3 ± 0.19 (S)
Iron:			
1. Aparri, Cagayan (Maximum)		6.4 ± 0.07	
2. San Vicente, Butuan, Agusan (Minimum)	(1) : (2)	2.0 ± 0.01	4.4 ± 0.07 (S)
3. Santiago, Isabela	(1) : (3)	5.9 ± 0.06	0.5 ± 0.09 (S)
4. Naga, Camarines Sur	(2) : (4)	2.8 ± 0.01	0.8 ± 0.01 (S)
5. Lumbatan, Lanao	(2) : (5)	5.9 ± 0.15	3.9 ± 0.15 (S)
6. Tiaong, Tayabas	(2) : (6)	3.0 ± 0.08	1.0 ± 0.08 (S)
Phosphorus:			
1. Ajuy, Iloilo (Maximum)		542.5 ± 5.77	
2. Tiaong, Tayabas (Minimum)	(1) : (2)	390.3 ± 3.82	142.2 ± 6.91 (S)
3. Naga, Camarines Sur	(1) : (3)	528.9 ± 1.14	13.6 ± 5.88 (I)
4. Santiago, Isabela	(2) : (4)	395.2 ± 1.35	4.9 ± 5.05 (I)
5. Libertad, Butuan, Agusan	(2) : (5)	526.0 ± 1.18	135.7 ± 3.99 (S)
6. Margosatubig, Zamboanga	(2) : (6)	398.9 ± 4.93	8.6 ± 6.23 (I)

[a] Calcium, iron, and phosphorus, in milligrams per 100 grams of oven-dry sample.
(S)—Significant
(I)—Insignificant

TABLE 4

Correlation between phosphorus pentoxide and calcium oxide contents of soil and of rice kernel

ORIGIN OF SAMPLES	PHOSPHORUS PENTOXIDE		CALCIUM OXIDE	
	Soil [a]	Rice kernel	Soil [a]	Rice kernel
	per cent	*per cent*	*per cent*	*per cent*
Balayan, Batangas	0.41	1.033	5.17	0.013
Batangas, Batangas	0.21	1.013	2.43	0.013
Hagonoy, Bulacan	0.19	1.336	3.23	0.019
Malolos, Bulacan	0.17	1.154	2.21	0.014
Tanay, Rizal	0.21	1.013	3.28	0.014
Tarlac, Tarlac	0.15	1.021	5.17	0.015
Coefficient of correlation.	(r) = –.3610 (Insignificant)		(r) = –.4111 (Insignificant)	

[a] Data from the soil survey reports of the Division of Soil Survey, Department of Agriculture and Commerce (Alicante *et al*, 1938).

TABLE 5

Correlation between the ratio or rainfall to temperature (Lang's rain factor) and the various inorganic constituents of rice grown in regions of distinct dry and wet seasons

ORIGIN OF SAMPLES	RAINFALL [a]	TEMPERATURE [b]	RAINFALL ÷ TEMPERATURE	CALCIUM mgm. per 100 grams oven-dry sample	IRON mgm. per 100 grams oven-dry sample	PHOSPHORUS mgm. per 100 grams oven-dry sample
	mm.	*°C.*				
Agricultural College, Laguna	2,217.7	27.0	82.1	11.6	5.8	508.3
Batangas, Batangas	1,665.7	27.0	61.6	9.3	4.9	437.8
Central Luzon Agricultural School, Nueva Ecija	1,888.0	27.0	69.9	8.7	4.0	534.8
General Trias, Cavite	2,066.2	27.0	76.5	10.4	4.7	359.9
Malolos, Bulacan	2,276.6	27.0	84.3	10.3	8.7	504.0
San Marcelino, Zambales	3,991.9	27.0	147.8	8.4	5.1	510.0
Santa Barbara, Pangasinan	2,487.1	27.0	92.1	14.5	5.1	488.1
Sibalom, Antique	4,099.5	27.0	151.8	19.4	8.5	480.0
Tanay, Rizal	2,917.2	27.0	108.0	10.9	3.3	443.1
Tanza, Cavite	2,585.1	27.0	95.7	10.3	4.5	463.8
Tarlac, Tarlac	2,176.0	27.0	80.5	10.8	5.0	446.1
Coefficient of correlation			$r = +.4893$ (I)		+.1049 (I)	+.2268 (I)

(I) Insignificant.
[a] Mean of 32 years.
[b] Mean of 16 years.

TABLE 6

Correlations between the ratio of rainfall to temperature (Lang's rain factor) and the various inorganic constituents of rice grown in regions of uniform rainfall

ORIGIN OF SAMPLES	RAINFALL [a]	TEMPERATURE [b]	RAINFALL ÷ TEMPERATURE	CALCIUM	IRON	PHOSPHORUS
				mgm. per 100 grams oven-dry sample	mgm. per 100 grams oven-dry sample	mgm. per 100 grams oven-dry sample
	mm.	°*C.*				
Aparri, Cagayan	2,269.8	27.1	83.7	14.2	6.4	472.8
Ajuy, Iloilo	2,351.7	27.0	87.1	9.0	4.3	542.5
Margosatubig, Zamboanga	1,076.7	27.1	39.8	11.3	4.3	398.9
Naga, Camarines Sur	2,342.8	26.3	89.0	8.9	2.8	528.9
Santiago, Isabela	1,790.5	27.1	66.0	8.4	5.9	395.2
San Vicente, Butuan, Agusan	2,272.7	26.6	85.4	8.3	2.0	468.8
Tiaong, Tayabas	2,081.6	26.6	78.2	10.1	3.0	390.3
Ubay, Bohol	1,781.8	26.3	67.7	9.4	3.0	440.4
Coefficient of correlation			r =	—.1551 (I)	+.2040 (I)	+.6989 (I)

[a] Mean of 31 years.
[b] Mean of 16 years.
(I) Insignificant.

TABLE 7

Analysis of data from the standpoint of rainfall

CONSTITUENTS	DISTINCT DRY AND WET	UNIFORM RAINFALL	DIFFERENCE
Calcium, milligrams [a]	11.3 ± 0.49	10.1 ± 0.36	1.24 ± 0.61 (I)
Iron, milligrams	5.3 ± 0.27	4.0 ± 0.27	1.30 ± 0.38 (S)
Phosphorus, milligrams	471.4 ± 8.52	462.5 ± 7.10	8.88 ± 11.09 (I)

[a]—Milligrams per 100 grams of oven-dry sample
(S)—Significant
(I)—Insignificant

A STUDY OF ROOT-NODULE BACTERIA OF CERTAIN LEGUMINOUS PLANTS [1]

SATURNINO S. POSADAS

WITH ONE TEXT FIGURE

Very little work has been done in the Philippines on the root-nodule bacteria (*Rhizobium leguminosarum* Frank). For this reason the study of the organism, the cross-inoculation power of the different strains, and their ability to fix nitrogen in the roots of plants were made. Dinglasan (1936) reports that more nodules formed in the roots of legumes planted in unsterilized than in sterilized soil. Aquino and Madamba (1939) state that seven strains of nodule bacteria showed great variations in their ability to fix nitrogen of the air in the host plants. Similarly, Agati and Garcia (1940) report that different isolates from soybean behaved differently.

According to Carroll (1934), certain strains of nodule bacteria of the cowpea cross-inoculation group showed greater power of nitrogen fixation than other strains in the group. He further states that the genera *Crotalaria* and *Pueraria* come within the cowpea group.

Georgi, Orcutt, and Wilson (1933) report that soluble nitrogen compounds available to plants are not fixed by free living forms of *Rhizobia*.

Allison, Ludwig, Hoover, and Minor (1940) state that the nodule bacteria oxidize only a very small portion of the total carbohydrate photosynthesized by the plants.

According to Whiting and Schoonover (1920), cowpeas formed nodules nine days after inoculation. They further noted that the progress of nitrogen fixation is related to the development of the plant.

Cases of reciprocity and non-reciprocity as a means of grouping the nodule bacteria on soybean and cowpea have been reported by Carroll (1934), Leonard (1933), Sears and Carroll (1927), Burton

---

[1] Experiment Station contribution No. 1433. Prepared in the Department of Soils under the direction of Assistant Professor Dionisio I. Aquino.

and Wilson (1939), Whiting and Hansen (1920), and Wilson, Burton, and Bond (1937).

MATERIALS AND METHODS

Legumes used

The legumes used were: *Crotalaria usaramoensis* E. G. Baker, *Pueraria javanica* Benth., *Tephrosia candida* (Roxb.) DC., *Tephrosia noctiflora* Bojer, and *Crotalaria juncea* Linn.

Isolation of the root-nodule bacteria to pure culture

Three to four well-developed nodules were taken from the roots (fig. 1) of each species of plants, thirty-five days old. The nodules were washed in running tap water and rinsed in distilled water several times. The surface was sterilized in a solution of mercuric bichloride (1:1000) for three to five minutes. The nodules were washed repeatedly in sterile distilled water and subsequently crushed in a test tube containing about ten milliliters of sterile distilled water. Serial loop dilutions of the bacterial suspension were then plated in the usual way (Fred and Waksman, 1928) by using mannitol agar.

The plates were incubated in an inverted position in the inoculation room at 27°C. Colonies of *Rhizobium leguminosarum* were seen in three to four days and were large enough to be transferred to agar solutions in seven to ten days. Only well-isolated colonies were transferred to congo red mannitol agar slants. These were labelled with the names of their hosts for use in experiments.

Cross-inoculation

Seeds of the legumes to be used in inoculation were sterilized with mercuric bichloride (1.1000) solution from four to five minutes and washed with three to five changes of sterile distilled water. The seeds were germinated on layers of sterile filter papers in Petri dishes.

The germinating seeds were planted in sterile seashore sand in 350-ml. porcelain tumblers, four seedlings in each tumbler. The sand was washed thoroughly with water and then dried in the sun. The dried sand was placed in tumblers. The tops were covered with Manila paper tied to the necks and later sterilized in the autoclave

for three successive days for two hours each at 15 pounds pressure. Previous to being planted, the seeds were inoculated with about ten milliliters of a bacterial suspension containing three loopfuls of a 48-hour old culture of *Rhizobium leguminosarum.* After emergence the seedlings were likewise inoculated. A circular opening was provided on the cover of each tumbler for the seedlings to pass through. The plants were watered with sterile distilled water as often as necessary, and once a week they received 40 ml. of sterile nitrogen-free Crone's solution.

Each series of cross-inoculation tests was accompanied by a control. The cultures were kept in the laboratory, but they were occasionally exposed to sunlight for a few hours. The nodules were counted first when the plants were one month and again when they were two months old. The bacteria were reisolated from these nodules.

The power of *Rhizobium leguminosarum* to cross-inoculate other species of legume was evaluated by the number of nodules produced and the air-dry weight of the plants.

Morphology

The form and size of *Rhizobium leguminosarum* were studied in permanent mounts from 48-hour old streak cultures kept at 27°C The bacteria were stained with carbol-fuchsin and mounted in Canada balsam. The stained bacteria were measured under the oil immersion objective with the aid of a filar micrometer.

Cultural characters

The growth, form, luster, elevation, and consistency of the bacterial streaks were studied on congo red mannitol agar slants at the age of one week. The size, surface elevation, topography, and edge of colonies were noted in plate cultures.

Physiology

The acid-forming characteristics of the various strains of *Rhizobium leguminosarum* were studied on mannitol and glucose agar slants, with brom-thymol-blue as indicator. The glucose agar medium was prepared as the mannitol agar except that glucose was substituted for the mannitol. Five milliliters of 0.5 per cent alcoholic

solution of brom-thymol-blue indicator were added to 1,000 ml. of the medium. The medium was adjusted to pH 7.0.

Nitrogen fixation

Each of the five strains of *Rhizobium leguminosarum* was inoculated to its respective host. The nitrogen content of the sand used was 0.0027 per cent, which was considered insignificant in evaluating the gain of nitrogen fixed owing to the inoculation. A control was provided for each inoculation experiment. Two sets of tests were made with plants of practically the same age as in the cross-inoculation tests.

The nodules of the plants were counted during the harvest. The tops and roots were air-dried. The air-dried plant tissues were weighed and cut into small pieces suitable for the determination of nitrogen. The amount of nitrogen was determined by the Kjeldahl method, described by the Association of Official Agricultural Chemists (1930). The difference in nitrogen contents between the inoculated and uninoculated plants was considered the amount of nitrogen fixed by the legume organisms.

RESULTS AND DISCUSSION

Morphology

The 48-hour old *Rhizobium leguminosarum* were rod-shaped with rounded ends. They varied slightly in length and in width (table 1). The cells of the *Crotalaria usaramoensis* strain were the widest with an average of 0.83 μ. The *Crotalaria juncea* strain was the smallest, being 1.08 $\times$ 0.57 μ. It appears that the slight differences in the measurements of the bacterial cells could be used for separating the different strains.

Cultural characters

Test-tube cultures. The five strains of *Rhizobium leguminosarum* grown on mannitol agar slants and incubated at 27°C. showed no marked difference in elevation and luster of growth. Of particular interest are the *Crotalaria* and *Pueraria javanica* strains, which exhibited a similar echinulate, raised, glistening, and moderately slimy growth. Wright (1925) found that some strains of the soybean bacteria showed a moderate to abundant and glistening growth,

whereas the *Calopogonium* strain exhibited scanty, filiform, raised, and whitish streaks on mannitol-agar slants. The *Crotolaria* and *Pueraria javanica* strains showed a moderate growth, which resembled that of the cowpea strain.

The *Tephrosia* strains were identical as to the manner of growth, both being scanty, beaded, raised, glistening, and noticeably slimy. These strains differ greatly from other nodule bacteria. Owing to these peculiar characteristics, the *Tephrosia* strains may be considered sufficiently distinct as to constitute a group. They are, therefore, tentatively designated as the *Tephrosia* group of *Rhizobium leguminosarum.*

The slimy clumps produced by the *Tephrosia* strains were broken in water after vigorous shaking. The moderately slimy clumps of the other strains readily spread, without vigorous shaking, into uniform suspension in water.

Plate cultures. The surface colonies of the bacteria on congo red mannitol agar in Petri dishes were circular, raised, smooth, moist, and transparent to translucent, with entire edges. The nodule organisms did not absorb the red dye. Colored colonies indicated contamination.

Variations were observed in the size of the colonies. Actual measurements made in one-week old plate cultures incubated at 27°C. showed that the colonies of *Crotalaria* and *Pueraria* bacteria were 1.5 to 3 mm. in diameter, whereas the *Tephrosia* strains were from 0.5 to 1.5 mm. across.

The buried colonies of the nodule bacteria were dense, translucent, spindle-shaped, with acute angles at the points. They also varied in size.

Physiology

In the glucose-agar medium the strain of *Rhizobium leguminosarum* from *Crotalaria juncea, Pueraria javanica,* and *Tephrosia candida* were slightly acid-forming, and those from *Crotalaria usaramoensis* and *Tephrosia noctiflora* were very slightly acid-forming (table 2).

Similar results were obtained on mannitol agar slants (table 2). The different strains with the exception of the *Crotalaria usaramoensis* strain maintained their acid-forming ability. Walker and Brown (1930) observed that the soybean strain produces an alkaline reaction, and the alfalfa, an acid reaction.

In general, the different strains of bacteria produced changes on the mannitol agar slant much slower than on the glucose agar. The glucose was fermented more rapidly than the mannitol. This is to be expected, as the mannitol is a more complex compound than the glucose. Baldwin and Fred (1927) observed the soybean and cowpea organisms to be alkaline producers; and the alfalfa, pea, bean, and dalea bacteria, acid producers.

Cross-inoculation experiments

The nitrogen-fixing power of the five strains of *Rhizobium leguminosarum* Frank on the different hosts studied are given in table 3.

Fig. 1.—Root systems showing young nodules of the legumes studied: (a) *Crotalaria juncea* Linn.; (b) *Crotalaria usaramoensis* Baker; (c) *Pueraria javanica* Benth.; (d) *Tephrosia candida* (Roxb.) DC.; and (e) *Tephrosia noctiflora* Boj.

When the strain of the bacteria from *Crotalaria juncea* were used to inoculate *Crotalaria usaramoensis* and vice versa, nodules (fig. 1) were produced in abundance in both cases. The two strains, however, differed slightly in that the *Crotalaria juncea* strain was able to produce more nodules in *Tephrosia candida* than the *Crotalaria usaramoensis* strain. On the other hand, the *Crotalaria usaramoensis* isolates produced more nodules in *Pueraria javanica* than the *Crotalaria juncea* isolates. The *Crotalaria juncea* organisms, however, produced more nodules in *Tephrosia noctiflora* than the

C. usaramoensis. These results show that the two strains from *Crotalaria* vary in their hosts range.

The *Pueraria javanica* strain produced nodules in *Crotalaria usaramoensis, Tephrosia candida,* and *Tephrosia noctiflora,* and to a much less extent, in *Crotalaria juncea.*

The nodule bacteria of *Tephrosia candida* formed abundant nodules on *Crotalaria juncea, Crotalaria usaramoensis,* and *Pueraria javanica.* On the other hand, these bacteria produced slight nodulations in *Tephrosia noctiflora.*

The *Tephrosia candida* strain produced the greatest number of nodules on plants one month old followed by the *Pueraria javanica* and the *Crotalaria strains.* The *Tephrosia noctiflora* strain produced the least. In the second trial, the nodule formation in all the inoculated plants increased. The *Crotalaria juncea* strain produced the greatest number of nodules on the different hosts, followed closely by the *Pueraria javanica* strain. *Tephrosia candida* and *Crotalaria usaramoensis* strains ranked third and fourth, respectively. The *Tephrosia noctiflora* strain produced the least. In all the plants inoculated with the different strains of bacteria, the efficiency with which nodules were formed in the roots appears to be an important basis for the grouping of the bacteria.

In the preceding tests, the *Tephrosia noctiflora* strains produced the least number of nodules in all the plants used, evidently showing that these bacteria belong to an entirely different group.

From the cross-inoculation tests the *Crotalaria juncea, Crotalaria usaramoensis, Pueraria javanica* and *Tephrosia candida* strains of bacteria are more or less similar and may be referred to the cowpea group. Carroll (1934) previously regarded the *Crotalaria* and *Pueraria* strains under the cowpea group. The *Tephrosia noctiflora* organism belongs to another group.

Nitrogen fixation

In all cases, the inoculated cultures showed a higher amount of nitrogen fixed after two months than those harvested after one month (table 4). In term of percentage of nitrogen, however, the one-month old plants showed a greater percentage of nitrogen than the two-month old.

The results further show that all the species of legumes inoculated varied greatly in the amount of nitrogen fixed. In the one-month old culture, the nodule bacteria from *Crotalaria usaramoensis*

were the best nitrogen fixers; and the *Tephrosia noctiflora* strains, the poorest. The plants which produced more nodules appeared darker than those with less.

In the two-month old cultures, the *Crotalaria usaramoensis* strains appeared the best nitrogen fixers. The *Pueraria javanica* strain fixed the lowest amount of nitrogen. The amounts of nitrogen fixed and the dry matter were greater in the plants inoculated than in those of the checks. As a rule the more nodules were formed, the more nitrogen was fixed in the plants.

SUMMARY

1. The strains of *Rhizobium leguminosarum* Frank from *Crotalaria juncea* Linn., *Crotalaria usaramoensis* E. G. Baker, *Pueraria javanica* Benth., *Tephrosia candida* (Roxb.) DC., and *Tephrosia noctiflora* Boj. were isolated, and their morphology, cultural characteristics, and physiology were studied.

2. They were all rod-shaped and varied slightly in size. The growth of the *Pueraria javanica* and *Crotalaria* strains appeared similar, but that of the *Tephrosia* strains exhibited a distinct growth. The *Crotalaria juncea, Pueraria javanica, Tephrosia candida, Crotalaria usaramoensis,* and *Tephrosia noctiflora* strains were slightly acid-forming.

3. The *Tephrosia candida* strain produced the greatest number of nodules on plants one-month old; the *Tephrosia noctiflora* strain formed the least. In the two-month old plants, the *Crotalaria juncea* strain produced the greatest number of nodules; the *Tephrosia noctiflora,* the least.

4. As a fixer of nitrogen, the strain of *Rhizobium leguminosarum* from *Crotalaria usaramoensis* was the best, followed by the *Crotalaria juncea,* the *Tephrosia noctiflora,* and the *Tephrosia candida* strains. The *Pueraria javanica* strain fixed the least amount of nitrogen.

5. The *Crotalaria juncea, Crotalaria usaramoensis, Pueraria javanica,* and *Tephrosia candida* strains are referred to the cowpea group. The strain on *Tephrosia noctiflora* belongs to a distinct group, tentatively designated as the *Tephrosia* group.

LITERATURE CITED

AGATI, JULIAN A., AND EUGENIA H. GARCIA. 1940. Studies on soybean nodule bacteria (*Rhizobium* sp.). Philippine Jour. Agric. 11: 271–284. *Pl. 1–3.*

ALLISON, F. E., C. A. LUDWIG, S. R. HOOVER, AND F. W. MINOR. 1940. Biochemical fixation studies: I. Evidence for limited oxygen supply within the nodule. Bot. Gaz. **101**: 513–533. *Text fig. 1–6.*

ANON. 1930. Official and tentative methods of analysis of the Association of Official Agricultural Chemists. 3rd. ed., xvii + 593 p. Washington, D. C.: Assoc. Off. Agric. Chemists.

AQUINO, DIONISIO I., AND AMBROSIO L. MADAMBA. 1939. A study of root nodule bacteria of certain leguminous plants. The Philippine Agriculturist **28**: 120-132. *Text fig. 1-2.*

BALDWIN, I. L., AND E. B. FRED. 1927. The fermentation characters of the root nodule bacteria of the Leguminosae. Soil Sci. **24**: 217–250.

BURTON, J. C., AND P. W. WILSON. 1939. Host plants specificity among the Medicago in association with root bacteria. Soil. Sci. **47**: 273–303.

CARROLL, W. R. 1934. A study of *Rhizobium* species in relation to nodule formation on the roots of Florida legumes: I. Soil Sci. **37**: 117–135. *Pl. 1; text fig. 1-4.*

DINGLASAN, MANUEL L. 1936. A study on the formation and nitrogen content of root tubercles of cowpea. The Philippine Agriculturist **25**: 168–190 *Text. fig. 1.*

FRED, E. B., AND S. A. WAKSMAN. 1928. Laboratory manual of general microbology with special reference to the micro-organisms in the soil. 145 p., 19 fig. New York: McGraw-Hill Book Co., Inc.

GEORGE C. E., F. S. ORCUTT, AND W. WILSON. 1933. Further studies on the relation between carbon assimilation and nitrogen fixation in leguminous plant. Soil Sci. **36**: 375–382.

GIOBEL, GUNNAR. 1926. The relation of the soil nitrogen to nodule development and fixation of nitrogen by certain legumes. New Jersey Agric. Exper. Sta. Bull. 436: 1-125. *Text. fig. 1-22.*

LEONARD, LEWIS T. 1923. Nodule-production kinship between the soybean and the cowpea. Soil Sci. **15**: 277–283.

SEARS, O. H., AND W. R. CARROLL. 1927. Cross-inoculation with cowpea and soybean nodule bacteria. Soil Sci. **24**: 413–419.

WAKSMAN, SELMAN A. 1932. Principles of soil microbiology. 2nd ed., 894 p., 83 fig., 14 pl. Baltimore: William and Wilkins Co.

WALKER, R. H., AND P. E. BROWN. 1930. Some fermentation characteristics of various strains of *Rhizobium meliloti* and *Rhizobium japonicum.* Soil Sci. **30**: 219–229. *Text fig. 1.*

WHITING, A. L., AND ROY HANSEN. 1920. Cross-inoculation studies with nodule bacteria of lime beans, navy beans, cowpeas, and others of the cowpea group. Soil Sci. **10**: 291–301.

WHITING, ALBERT L., AND WARREN R. SCHOONER. 1920. Nitrogen fixation by cowpeas and nodule bacteria. Soil Sci. **10**: 411–420.

WILSON, P. W., S. C. BURTON, AND V. S. POND. 1937. Effect of species of host plants on nitrogen fixation on melilotus. Jour. Agric. Res. **55**: 619–629.

TABLE 1

Size and shape of the nodule bacteria from 48-hour old cultures

STRAINS OF NODULE BACTERIA	AVERAGE SIZE	SHAPE
	μ	
Crotalaria juncea Linn.	1.08 × 0.57	Rod-shaped with rounded ends
Crotalaria usaramoensis Baker	1.32 × 0.83	Rod-shaped with rounded ends
Pueraria javanica Benth.	1.32 × 0.62	Rod-shaped with rounded ends
Tephrosia candida (Roxb.) DC.	1.06 × 0.60	Rod-shaped with rounded ends
Tephrosia noctiflora Boj.	1.19 × 0.61	Rod-shaped with rounded ends

TABLE 2

Fermentation characteristics of five strains of nodule bacteria when grown on glucose agar and on mannitol agar slant pH 7.0 with brom-thymol-blue as indicator

STRAINS OF NODULE BACTERIA	GLUCOSE AGAR		MANNITOL AGAR	
	No. of days before yellowing begins [a]	No. of days before yellowing is completed [a]	No. of days before yellowing begins [a]	No. of days before yellowing is completed [a]
Crotalaria juncea Linn.	2–3	6–7	2–3	23–28
Crotalaria usaramoensis Baker. ..	5–7	17–18	1–3	25–31
Pueraria javanica Benth.	2–4	7–11	12–14	26–30
Tephrosia candida (Roxb.) DC. ..	2–3	5–7	11–13	25–28
Tephrosia noctiflora Boj.	6–7	15–17	11–13	27–32

[a] Range of ten trials.

TABLE 3

Nitrogen fixation of five strains of nodule bacteria in cross-inoculation tests

SOURCE OF INOCULUM	PLANTS INOCULATED	1ST TRIAL, 1 MONTH OLD		2ND TRIAL, 2 MONTHS OLD	
		No. of nodules on 4 plants	Air-dry wt. of 4 plants	No. of nodules	Air-dry wt. of 4 plants
Crotalaria juncea	*Crotalaria juncea* (Uninoculated)	0	0.2892	0	0.6321
	Crotalaria juncea	21	0.6112	39	1.8503
	Crotalaria usaramoensis	15	0.1985	23	1.2503
	Pueraria javanica	1	0.1148	9	0.6537
	Tephrosia candida	5	0.1535	17	0.9348
	Tephrosia noctiflora	3	0.1108	11	0.7245
Crotalaria usaramoensis	*Crotalaria usaramoensis* (Uninoculated)	0	0.1023	0	0.2850
	Crotalaria usaramoensis	17	0.2524	31	1.2803
	Crotalaria juncea	21	0.3044	27	1.6358
	Pueraria javanica	5	0.1124	12	0.3891
	Tephrosia candida	1	0.1140	5	0.2156
	Tephrosia noctiflora	1	0.1055	2	0.2053
Pueraria javanica	*Pueraria javanica* (Uninoculated)	0	0.0816	0	0.2904
	Pueraria javanica	19	0.1800	28	1.0084
	Crotalaria juncea	2	0.1200	8	0.3205
	Crotalaria usaramoensis	18	0.1736	30	0.7506
	Tephrosia candida	11	0.1236	19	0.5873
	Tephrosia noctiflora	5	0.1138	12	0.3325
Tephrosia candida	*Tephrosia candida* (Uninoculated)	0	0.1200	0	0.2596
	Tephrosia candida	23	0.3859	26	1.3008
	Crotalaria juncea	13	0.1301	20	0.5679
	Crotalaria usaramoensis	25	0.1856	21	1.1013
	Pueraria javanica	16	0.1213	20	0.4023
	Tephrosia noctiflora	1	0.0958	3	0.1934
Tephrosia noctiflora	*Tephrosia noctiflora* (Uninoculated)	0	0.1048	0	0.2380
	Tephrosia noctiflora	6	0.1458	13	0.9053
	Crotalaria juncea	3	0.1237	10	0.6892
	Crotalaria usaramoensis	1	0.1006	5	0.3254
	Pueraria javanica	3	0.1299	8	0.7463
	Tephrosia candida	5	0.1673	15	0.9323

TABLE 4

Nitrogen fixation by root nodule bacteria in inoculated legumes

ONE-MONTH OLD PLANTS

STRAINS OF NODULE BACTERIA	NODULE NUMBER	AIR-DRY WT. OF 4 PLANTS	NITROGEN	TOTAL NITROGEN IN PLANTS	AMT. OF NITROGEN FIXED	AVERAGE AMOUNT OF NITROGEN FIXED
		grams	*per cent*	*mgm.*	*mgm.*	*mgm.*
Crotalaria juncea Linn.						
Uninoculated	0	0.2125	3.01	6.40	—	
Inoculated	15	0.4892	3.41	16.68	10.28	8.86
Inoculated	8	0.3998	3.46	13 83	7.43	
Crotalaria usaramoensis Baker						
Uninoculated	0	0.1200	2.82	3 38	—	
Inoculated	11	0.2356	2.99	7.04	3 66	8.89
Inoculated	21	0.5928	2.95	17.49	14.11	
Pueraria javanica Benth.						
Uninoculated	0	0.0958	1.53	1.47	—	
Inoculated	13	0.1856	2.77	5.14	3.67	3 53
Inoculated	15	0.1756	2.76	4.85	3.38	
Tephrosia candida (Roxb.) DC.						
Uninoculated	0	0.1365	2.91	3.97	—	
Inoculated	16	0.2587	3.21	8.30	4.33	3.38
Inoculated	12	0.1998	3.20	6.39	2.42	
Tephrosia noctiflora Boj.						
Uninoculated	0	0.1253	2.70	3.38	—	
Inoculated	8	0.1548	2.90	4.49	1.11	0.92
Inoculated	10	0.1452	2.83	4.11	0.73	
TWO-MONTH OLD PLANTS						
Crotalaria juncea Linn.						
Uninoculated	0	0.5896	2.73	16.10	—	
Inoculated	25	1.3221	2.99	39.53	23.43	25.02
Inoculated	30	1.4332	2.98	42.71	26.61	
Crotalaria usaramoensis Baker						
Uninoculated	0	0.3503	2.31	8.09	—	
Inoculated	20	1.1723	2.79	32.71	24.62	30.51
Inoculated	31	1.5832	2.81	44.49	36.40	
Pueraria javanica Benth.						
Uninoculated	0	0.2145	2.02	4.33	—	
Inoculated	19	0.9112	2.73	24.88	20.55	22.49
Inoculated	27	1.1232	2.56	28.75	24.42	
Tephrosia candida (Roxb.) DC.						
Uninoculated	0	0.2356	2.31	5.44	—	
Inoculated	21	1.1232	2.93	32.91	27.47	24.93
Inoculated	18	1.1001	2.53	27.83	22.39	
Tephrosia noctiflora Boj.						
Uninoculated	0	0.2058	2.50	5.15	—	
Inoculated	18	1.1582	2.67	30.92	25.77	27.88
Inoculated	21	1.3256	2.65	35.14	29.99	

LABOR REQUIREMENT AND COST OF GROWING CORN WITH MACHINERY AND NATIVE IMPLEMENTS [1]

ALEJANDRO B. CATAMBAY AND HIGINO R. MARQUEZ
Of the Departments of Agricultural Engineering and Agronomy

A large majority of our farmers still practice old cultural methods in the growing of corn. Practically all operations are done by hand. The cost of production of this crop is still considered high and may yet be reduced by improving the method of culture. This may be accomplished by the use of machinery.

The labor requirement and the cost of growing corn with machinery and with native implements were studied in order that pertinent data on this work may help private and government farming entities, which are now planting big areas of land to this crop.

Varona (1929) found that planting corn with the corn planter consumed less time and labor than the hand method of planting. He found also that the total cost of operation was less with the corn planter method than with the hand method.

Samonte [2] found that the time required for plowing was very much shorter with the tractor and disc plow than with the native plow and bullock. He also found that shelling corn with a sheller cost less and required less time than by hand.

In the United States, McCuen (1927), Jones (1931), Dunca (1933), and Walster (1937) report that labor efficiency could be greatly improved by changing hand to machine labor.

MATERIALS AND CULTURAL OPERATIONS

The seed

Calauan Yellow Flint corn was used. The seed used in the wet season culture was obtained from the 1940 dry-season harvest of the Annual Farm Crops Division, Department of Agronomy. For the dry season planting, the seed was obtained from the 1940 wet-season harvest of the Department of Animal Husbandry.

---

[1] Experiment Station contribution No. 1434.

[2] SAMONTE, HONORIO R. The cost of producting corn with machinery. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1931. Unpublished).

Equipment

Tractor. A McCormick-Deering "Farmall 12", model 1938, was used in plowing, harrowing, planting, and cultivating.

Tractor plow. A McCormick-Deering No. 90 direct-connected plow was used in plowing the field.

Disc harrow. The La Crosse disc harrow was used in harrowing the lot which had been plowed with the tractor plow.

Corn planter. A McCormick-Deering No. 20 Corn Drill and Planter was used in planting the lot using machinery.

Cultivator. A McCormick-Deering No. 215-H Cultivator was used in cultivating the lots prepared by machinery. The cultivator is attached to the tractor.

Corn sheller. The International Harvester Two-Hole Corn Sheller was used in shelling corn raised by machinery. It is run by an electric motor.

Native plow. The native plow of the upland type was used in plowing, furrowing, and cultivating the field treated with the native method. It has a wooden beam and cast iron moldboard and share.

Native spike-tooth harrow (*calmot*). For harrowing the field treated with the native method, the calmot was used. This implement is made of fourteen bamboo stubs about a meter long, fastened together by two long pegs.

Native hand sheller. A wooden home-made sheller was used in shelling the corn raised with the native method. It is made of a block of wood 50 centimeters long, 8 centimeters wide, and 4 centimeters thick. One face is concave to fit the ears of corn as they are made to slide over it. It has a hole in the middle about three centimeters long and two centimeters wide. At the edge of the hole in the middle of the block is an iron peg about five centimeters long and 1½ centimeters wide. As the ears of corn are forced to slide on the concave surface, the peg catches the grains and removes them from the cob. The grains fall through the hole. About two to three rows of grains are removed at one stroke.

The field

Area. The area of the land used in this study was four hectares. The first two hectares of land used during the wet season are located

in the Agronomy Experiment Station. The other two fields used during the dry season are located in the Department of Animal Husbandry grounds.

Division of field into lots. The field used during the wet season was divided into two one-hectare lots. During the dry season another field was divided into two one-hectare lots. In order that these lots might be easily identified, they were numbered I to IV. Lots I and III were for machinery for the wet and dry seasons, respectively. Lots II and IV were for native implements for the wet and dry seasons respectively.

Soil. The soil in both cases is of the clay loam type.

The lot used during the wet season had been previously planted to sugar cane; and during the dry season, to corn. In both cases the fields were not fertilized.

Preparation of land

Plowing. Lots I and II, which constitute the wet season culture, were plowed in May, 1940. Lot I was plowed with a tractor drawn plow, and lot II, with the native plow. Two plowings at about two weeks interval were required to prepare the fields.

Lots III and IV were plowed in September, 1940. They required two plowings, lot III with the tractor plow and lot IV with the native implement.

Harrowing. Lots I and II were harrowed with a tractor-drawn disc harrow after each plowing. Likewise, lots II and IV were harrowed thoroughly with the calmot after each plowing.

Furrowing

Lots I and III, which were used for machinery were not furrowed by a special operation because the corn planter furrows and plants at the same time. Lots II and IV were furrowed with the native plow. The furrows were laid about one meter apart.

Planting

A machine planter pulled by the tractor was used in planting lots I and III. It planted two rows at a time. Three or four seeds were dropped in each hill. The furrows were about one meter apart and about eighty centimeters between hills.

Lots II and IV were planted by hand after the furrows had been laid. Three to four kernels of corn were dropped in each hill. The seeds were covered with soil by the feet. The distance between hills ranged from 60 to 80 centimeters.

Cultivation

In both the wet and dry season cultures, cultivation was done about one month after planting. Lots I and III were cultivated by a tractor-drawn cultivator. Lots II and IV were cultivated with the native plow.

Harvesting

The crop from all cultures were harvested by hand. The ears were plucked from the stalks and then husked before being hauled by bull carts to the drying floor of the Department of Agronomy.

Shelling

The harvest from lots I and III was shelled with a machine sheller hitched to an electric motor, whereas that from lots II and IV, with a home-made corn sheller.

RESULTS AND DISCUSSION

Field observation on the size and vigor of the plants in each lot

The plants in both lots grew vigorously, although the ones in lots I and III were smaller than those in lots II and IV. This may be attributed to the effect of cultivation, because the plants in both lots were practically the same in appearance in the wet and dry season cultures before cultivation. After cultivation, the plants showed marked differences in size and vigor. These differences may be attributed to the fact that in cultivating with the native plow, the base of the plants was thoroughly covered and properly hilled up. With the cultivator in lots I and III, the soil, although stirred deeply and thoroughly, did not cover the base of the plants, and thus exposed for the most part their brace roots.

Labor requirement and cost

Table 1 shows the labor requirement and cost involved in each operation in both cultures. With machinery, it required 101.1 man and three animal hours to work the whole hectare in the wet season,

involving a cost of ₱14.58. In the dry season, 120.9 man and four animal hours were required to raise corn with a cost of ₱17.12. The native implements used, on the other hand, required 294.3 man and 160.7 animal hours in the wet season, and 327.4 man and 159.4 animal hours in the dry season to raise corn in the same area. The cost incurred was ₱56.90 and ₱60.87 for the wet and dry seasons respectively.

The difference in labor cost between the two methods was ₱42.32 in the wet season and ₱43.75 in the dry season in favor of the modern method. These results show that labor requirement can be greatly reduced with machinery. One decided advantage in using farm machinery over native implements is that the work can be accomplished in a much shorter time.

If the figures in both seasons are considered, it took an average of 30.6 man hours to prepare one hectare of land, plant it, and then cultivate the crop with the tractor and tractor implements, whereas 163.6 man hours were spent for doing the same work with the native implements and work animals.

In shelling the corn with a two-hole corn sheller hitched to an electric motor, 15 cavans of the grain were obtained in 2.2 hours. With a home-made corn sheller it would take a man from 70 to 80 hours to shell the same amount.

Itemized and total cost of production

Table 2 shows the charges for the use of machinery and implements for the two season cultures. Lot I and III, because of the heavy investment on the equipment, involved a total of ₱9.51 and ₱9.45, respectively. Lots II and IV incurred expenses of ₱1.44 and ₱1.33, respectively. The charges for the use of equipment were computed by the following formulae by Catambay (1931):

$$\text{Depreciation per day in pesos} = \frac{cd}{ym}$$

$$\text{Interest per day in pesos} = \frac{crd}{365}$$

Where c = Cost of machinery or implement in pesos
d = Number of days used (8 hours a day)
y = Life of implements in years
m = Maximum number of days that the implement or machine is used in one year
r = Rate charge for interest, repair, and housing of implements.

Table 3 shows a land rent of ₱7.41 for each of the four lots. The land was used in all cases for a period of 4-1/2 months. The computation was based on ₱20 per hectare for one year, which is the average rental around Los Baños, Laguna.

The cost of seeds for lots I and III was ₱0.70 each. A fixed adjustment in the machine planter made the number of seeds falling per hill more or less constant. Three and one-half gantas of seeds were planted in each of the two lots. Lots II and IV required 6-1/2 gantas of seeds each. More seeds than necessary were often dropped by the man doing the planting. Each lot involved a seed cost of ₱1.30.

The values of fuel and lubricant used in lot I were gasoline, ₱0.62; kerosene, ₱14.98; oil, ₱2.06; and grease, ₱0.47. The total cost for these items was ₱18.13. Lot III, which was also used for machinery, incurred a total expense of ₱17.43 for fuel and lubricant.

The electric motor for the sheller used three kilowatt-hour for the harvest in lot I and four kilowatts for that in lot III. At seven centavos per kilowatt-hour, the value of the current consumed was ₱0.21 for lot I and ₱0.28 for lot III.

The total cost of supplies and land rent for the two season cultures was ₱26.51, ₱8.77, ₱25.88, and ₱8.77 for lots I, II, III, and IV, respectively.

Table 4 shows the total cost of production per hectare of the crop. The interest on the average working capital is included in table 4. It was based on the total of labor cost, land rent and supplies, and depreciation of machinery and implements charged at seven per cent. The item amounted to ₱0.63, ₱0.90, ₱0.66, and ₱0.93 for lots I, II, III, and IV, respectively.

The total cost of producing one hectare of the crop with machinery was ₱51.23 for the wet season and ₱53.11 for the dry. The average for the two seasons was ₱52.17.

With the native method, one hectare of the crop raised during the wet season cost ₱68.01 and ₱71.90 during the dry. The average was ₱69.96. If the comparison is based on the averages for the two seasons, it cost ₱17.79 less to raise corn with machinery than with native implements.

Cost of producing one cavan of shelled corn

Table 5 shows the cost of producing one cavan of the grain. With machinery it cost ₱3.53 and ₱3.48 during the wet and dry sea-

sons respectively, the average being ₱3.51. The costs obtained from the lots treated with the native implements were ₱5.48 and ₱4.49 with an average of ₱4.99. The average obtained from the lots worked out with machinery was ₱1.48 less than that obtained from the lots treated with native implements.

The figures obtained in this study are higher than those of Samonte [3], who found that the average cost of producing one cavan shelled corn was ₱4.81 during the wet season and ₱2.61 during the dry. The difference may be attributed to the high yields which he obtained. The average production from his culture was 25.31 cavans from the crop raised with native implements and 27.87 from the lot where machinery was used. The average yield found in this study was 14.20 cavans in the lots treated with the native implements and 14.88 cavans in the lots where machinery was employed. The difference between the yields may perhaps be due to the fact that Samonte [4] used newly-opened land whereas the writers used fields that had been continuously farmed for more than 10 years. The writers' cost of production per hectare of the crop is lower than that of Samonte.[5]

Rate of profit or loss in the cost of production

The selling price of shelled corn in the College, just after the crop was harvested, was ₱2.50 per cavan. The average cost of production with the native implements was ₱4.99 per cavan and with machinery, ₱3.51. The loss incurred per cavan was ₱2.49 from the crop raised with native implements and ₱1.01 from that raised with machinery, or 49.9 per cent and 28.78 per cent, respectively. From the results of this study, which are corroborated by those of Samonte's [6] under conditions reported in this work, corn may not be considered a profitable crop. It will be noted that the area used in this study was four hectares and that of Samonte [7] 10.5 hectares so that the figures obtained may be considered representative from which to draw conclusions. If the average yield in the Philippines will be considered, the loss incurred would have been greater. The latest figures show that the average yields in the Philippines were 11.64 cavans per hectare in 1937 and 12.5 cavans in 1938 [8].

[3, 4, 5, 6, 7] See footnote 2.

[8] Bulletin of Philippine Statistics. Vol. 6, First and Second Quarters, 1939. Published by the Department of Agriculture and Commerce.

If the average cost of production with machinery is considered as ₱52.17 per hectare of the crop and ₱69.96 with native implements and on the basis of the current price of ₱2.50 per cavan, the production should be not be less than 20.87 cavans per hectare with machinery and 27.96 cavans with native implements. Corn should therefore, be grown as a money crop only in regions with favorable climate and with fertile soil, where the yield could be expected to exceed 20.87 cavans per hectare when raised with machinery and 27.96 cavans when native implements are used.

SUMMARY

1. Two plowings with the tractor and tractor-mounted 16-inch moldboard plow required 18 hours, or an average of nine hours, per hectare for each operation. With the native plow, two operations required an average of 114.5 hours, or about 57.3 hours per hectare for one plowing.

2. Harrowing with a tractor-drawn disc harrow required 5 hours or 2.5 hours per hectare per operation. Harrowing one hectare of land thoroughly took 16 hours, or eight hours per harrowing.

3. Furrcwing with the native plow consumed an average of 7.2 hours per hectare.

4. Planting with machinery required an average of 3.3 hours per hectare. It included furrowing. Planting alone by hand consumed 7.0 hours per hectare.

5. Cultivation with machinery required an average of 4.4 hours per hectare and with the native plow, 18.8 hours.

6. Harvesting one hectare of the crop required an average of 73.8 hours. This operation included hand plucking of ears from the stalks, husking, and piling them ready for hauling.

7. In general less labor was required to raise the crop with machinery than with native implements.

8. The total cost of production per hectare of the crop with machinery was ₱51.23 during the wet season and ₱53.11 during the dry, with an average of ₱52.17. With the native implements the cost involved was ₱68.01 during the wet season and ₱71.90 during the dry, the average being ₱69.96. It cost ₱17.79 less to raise one hectare of the crop with machinery than with the native implements. The average cost of producing one cavan of shelled corn for the two seasons was ₱4.99 with the native implements and ₱3.51 with machinery.

9. A loss was incurred in the production of the crop. The loss from the crop raised with native implements was 49.9 per cent and from that raised with machinery, 28.78 per cent. Corn should not be considered a money crop where the yield is lower than 20.87 cavans per hectare when raised with machinery and 27.96 cavans when raised with native implements.

LITERATURE CITED

CATAMBAY, A. B. 1931. Plows and plowing: IV. Cost of plowing with different plowing outfits. The Philippine Agriculturist **20**: 410–422.

DUNCA, J. R. 1933. Rate of planting corn for grain. Michigan Agric. Exper. Sta. Bull. 15: 292-293.

JONES, D. E. 1931. How farm cost can be cut; a comparison of tractor and horse power. Bankers' Monthly **48**: 407–409.

MCCUEN, G. W. 1927. Latest development in the motorization of corn production. Agric. Engin. **8**: 279–281.

VARONA, A. P. 1929. Study of two methods of planting corn with corn planter and by hand. The Philippine Agriculturist **18**: 217–224.

WALSTER, H. L. 1937. What has machine done to agriculture? Rural American **15**: 10—20.

TABLE 1

Labor requirement and cost [a]

OPERATION	KIND OF LABOR	LOT I Number of hours	LOT I Labor cost	LOT II Number of hours	LOT II Labor cost	LOT III Number of hours	LOT III Labor cost	LOT IV Number of hours	LOT IV Labor cost
			pesos		*pesos*		*pesos*		*pesos*
Plowing:									
1st plowing	Man	10.0	1.75	60.0	7.50	10.0	1.75	60.0	7.50
	Animal			60.0	7.50			60.0	7.50
2nd plowing	Man	8.0	1.40	55.0	6.88	8.0	1.40	54.0	0.75
	Animal			55.0	6.88			54.0	0.75
Harrowing:									
1st harrowing	Man	2.5	0.44	8.0	1.00	2.5	0.44	8.0	1.00
	Animal			8.0	1.00			8.0	1.00
2nd harrowing	Man	2.5	0.44	8.0	1.00	2.5	0.44	8.0	1.00
	Animal			8.0	1.00			8.0	1.00
Furrowing	Man	3.5	0.61	7.2	0.90	3.0	0.53	7.5	0.94
	Animal			7.2	0.90			7.5	0.94
Planting	Man			7.0	0.88			7.0	0.88
Cultivation	Man	4.7	0.82	19.5	2.44	4.0	0.70	18.0	2.25
	Animal			19.5	2.44			18.0	2.25
Harvesting and hauling	Man	62.5	7.81	67.5	8.44	82.5	10.31	82.5	10.31
	Animal	3.0	0.38	3.0	0.38	4.0	0.50	4.0	0.50
Shelling	Man	7.4	0.93	62.1	7.76	8.4	1.05	82.4	10.30
Total			14.58		56.90		17.12		60.87

[a] Machinery were used on lots I and III, and native implements on lots II and IV. The tractor driver received a wage of ₱0.175 an hour and all other laborers, ₱0.125. Animal labor was valued at ₱0.125 an hour.

TABLE 2

Charges for the use of machinery and implements [a]

KIND OF IMPLEMENT	COST	MAX. DAYS (8 HR.) USED IN ONE YEAR	LIFE	LOT I Hours used	LOT I Depreciation	LOT I Interest	LOT II Hours used	LOT II Depreciation	LOT II Interest	LOT III Hours used	LOT III Depreciation	LOT III Interest	LOT IV Hours used	LOT IV Depreciation	LOT IV Interest
	pesos	*8-hr. days*	*years*	*hours*	*pesos*	*pesos*	*hours*	*pesos*	*pesos*	*hours*	*pesos*	*pesos*	*hours*	*pesos*	*pesos*
Farmall Tractor F-12 ..	1600.00	140	8	31.2	5.62	1.87				30.0	5.40	1.80			
Farmall moldboard plow —16"	212.50	100	7	18.0	0.72	0.18				18.0	0.72	0.18			
La Crosse Disc Harrow	98.18	100	10	5.0	0.05	0.01				5.0	0.05	0.01			
Planter & Drill	204.00	100	10	3.5	0.11	0.04				3.0	0.09	0.03			
Cultivator	246.50	100	10	4.7	0.14	0.05				4.0	0.12	0.04			
International Harvester 2-hole corn sheller ..	116.00	100	5	7.4	0.10	0.01				8.4	0.34	0.03			
Electric motor and accessories	565.50	100	15	7.4	0.37	0.16				8.4	0.39	0.16			
Native plow	15.00	100	4				141.7	0.71	0.58				139.5	0.70	0.47
Native spike tooth harrow or *calmot*	5.00	100	3				16.0	0.05	0.01				16.0	0.05	0.01
Native hand corn sheller	1.00	100	3				62.1	0.02	0.00				82.5	0.03	0.00
Bull cart	75.00	100	5	3.0	0.07	0.01	3.0	0.06	0.01	4.0	0.08	0.01	4.0	0.06	0.01
Total					7.18	2.33		0.84	0.60		7.19	2.26		0.84	0 49

[a] Ten per cent was the rate charged for annual interest, repair, and housing of machinery and implements.

TABLE 3

Cost of supplies and land rent

ITEMS	WET SEASON		DRY SEASON	
	Lot I (Modern)	Lot II (Native)	Lot III (Modern)	Lot IV (Native)
	pesos	*pesos*	*pesos*	*pesos*
Land rent	7.47	7.47	7.47	7.47
Supplies:				
Seed	0.70	1.30	0.70	1.30
Fuel for tractor:				
Petroleum	14.98	—	14.40	—
Gasoline	0.62	—	0.60	—
Lubricant for:				
Tractor	2.06	—	1.98	—
Implements	0.47	—	0.45	—
Electricity for motor	0.21	—	0.28	—
Total	26.51	8.77	25.88	8.77

TABLE 4

Cost of production per hectare

ITEMS	WET SEASON		DRY SEASON	
	Lot I (Modern)	Lot II (Native)	Lot III (Modern)	Lot IV (Native)
	pesos	*pesos*	*pesos*	*pesos*
Labor cost	14.58	56.90	17.12	60.87
Charges for the use of machinery and implements	9.51	1.44	9.45	1.33
Supply cost and land rent	26.51	8.77	25.88	8.77
Interest on average working capital at 7%	0.63	0.90	0.66	0.93
Total	51.23	68.01	53.11	71.90

TABLE 5

Cost of producing one cavan of shelled corn

CULTURE	COST OF PRODUCTION PER HECTARE	YIELD	COST OF PRODUCING A CAVAN OF SHELLED CORN
	pesos	*cavans*	*pesos*
Native method:			
Wet season	68.01	12.40	5.48
Dry season	71.90	16.00	4.49
Modern method:			
Wet season	51.23	14.50	3.53
Dry season	53.11	15.25	3.48

THE LAND SETTLEMENT PROJECT AT KORONADAL AFTER ITS FIRST YEAR, 1939-1940 [1]

JOSÉ E. VELMONTE [2]
Of the Department of Agricultural Economics

WITH FOUR TEXT FIGURES

From March 16 to April 14, 1940, a trip to Mindanao was made primarily to observe conditions in Koronadal, the seat of the first land settlement project of the government under the direction of the National Land Settlement Administration. With work progressing at a very fast rate in Koronadal, some of these observations will be found to be out of date. One cannot readily comprehend the vastness of the project at Koronadal and the multiplicity of the problems that have to be faced by the National Land Settlement Administration in carrying out organized land settlement on a large scale unless he visits the region and lives for a while with the settlers.

Koronadal is a vast plain in the heart of Cotabato province comprising nearly 100,000 hectares of level land. The National Land Settlement Administration hopes to bring over no less than half a million people established as farm owners in model communities in about ten years. This seems to be no idle hope for its record during its first two years shows that after the first year, no less than 1,500 settlers and members of their families have been established in new homes; and after the second year, the number has reached nearly 9,000.

During the last four decades, the public land policy has been directed towards encouraging the people to move south and acquire a portion of the agricultural public domain under most liberal terms. Individual acquisition, however, has proved to be a pitifully slow and expensive process of settling the public domain. Converting virgin land into a farm requires sustained energy and great expense often far beyond what the individual settler could meet. Even the first

---

[1] General contribution No. 781. Under a different title the greater part of the materials of this paper was read before the University of the Philippines Alumni Institute, April 17, 1941.

[2] Acknowledgment is hereby made to the officials of the National Land Settlement Administration for the many courtesies extended the writer during his stay at Koronadal in March, 1940.

colonization ventures of the government were not entirely successful largely because of limited financial support and also because these schemes were hardly more than transporting settlers to the new region and then leaving them entirely on their resources shortly afterwards. It is now realized that government support has to be sustained until farms are put on a producing basis and communities have to be planned so as to establish in the new region as much as possible the social life of the communities where the settlers are drawn from.

The creation of the National Land Settlement Administration with an appropriation of ₱20,000,000 made possible organized land settlement on a large scale under government direction. Koronadal is the first project under the NLSA where a settler is helped in every possible way by the government to found a new home and to acquire and operate a farm freed from many obstacles that beset an individual settler who goes south on his own. The first batch of settlers arrived at Koronadal on February 27, 1939, so that when this visit was made, the settlement was almost a year old.

THE COLONIZATION PLAN

Model community sites were selected and carefully planned. Settlers are drawn from all regions of the country and efforts in selecting them on the basis of merit, health, and agricultural background are being made. A settler and his family are allowed a maximum amount as advance, or loan, of ₱1,200. His transportation expenses to the settlement are charged against this amount. He uses a part of this to build a modest house. He subsists on this while his farm is being made ready for production. He equips himself with farm and garden tools as well as work animals from this amount. This loan bears interest at 4 per cent and is payable in twenty years. The energy of the National Land Settlement Administration is bent on hastening the establishment of the settler's farm and having him put it as quickly as possible on production basis for the total advances allowed him of ₱1,200 is not by any means very large.

Almost immediately upon arrival, a settler is given in the townsite, that has been carefully planned, a home lot of 2,000 square meters on which his house may be built. He does this largely with his own labor. Vegetables are immediately raised primarily for family requirements. A farm of 12 hectares is given the settler later. Half of the area is devoted to money crops and the other half to food crops.

The National Land Settlement Administration operates large farms for experimental purposes. Seeds and planting materials are being made available to settlers at nominal cost. Hog and poultry farms will eventually furnish stock to settlers. Technical advice in raising crops is furnished. Farm machinery is also available to the settler at nominal charges especially for breaking and plowing the land. In short, everything is done to help the settler establish a profitable farm, a productive garden lot, and a community and home better than what he has left behind—the prospect of enjoyment of a standard of living above subsistence level.

Fig. 1.—Settlers disembarking at Dadiangas.

ACCOMPLISHMENTS DURING THE FIRST YEAR

Three settlements were established, Lagao, Tupi, and Marbel. Lagao is the southernmost settlement about three kilometers from the port of Dadiangas. It was made the site of the first settlement with the first group of settlers that came with the administration officials on February 27, 1939. The offices of administration are located here. Tupi, about 40 kilometers north of Lagao, was opened as a second settlement in September 1939; and Marbel, 25 kilometers farther north, was established as the third settlement in January, 1940.

Settlers at Lagao were 210 with 471 dependents; at Tupi, 137 with 455 dependents; and at Marbel, 45 with 144 dependents. Altogether there were established on these settlements 392 settlers with 1,070 dependents, or an average family, or household of nearly 4 persons. By March, 1940, Marbel had already 101 settlers with 282 dependents.

At Lagao in December 1939, 178 home lots were distributed; by March, 1940, of the 296 settlers, 251 were established with home lots. A total of 112 houses were already constructed and 44 more were under construction. A majority of these houses cost less than ₱80

Fig. 2.—A settler's home and garden at Lagao.

each. The first houses at Lagao, however, cost from two to as high as four times this amount because they were built of materials not obtained locally.

At Tupi, by December, 1939, all settlers have been assigned to home lots. On these, 26 houses were already built and 49 more were under construction. These houses cost only ₱30 each, much less than those at Lagao. By March, 1940, 140 houses were already constructed.

Marbel was just opened during the visit, but already 99 home lots were distributed and 70 homes were under construction.

The administration had farms in operation at Lagao planted to cotton, peanuts, and other crops totalling over 200 hectares; a hog farm which was already a large project at the end of the first year; and an equally large poultry project. These will eventually furnish seed and foundation stock to settlers in Koronadal. A store that supplies the settlers with all their needs was in operation at Lagao with branches in the other settlements. The administration has already acquired farm machinery used primarily to open new land for administration farms as well as for settlers' farms.

It will be noted that during the first year, settlers have not as yet received their farm lots of 12 hectares. At the time of the visit,

Fig. 3.—Settlers' homes at Tupi along the national highway under construction.

surveyors were still busy subdividing the area into farm lots with the expectation of finally distributing them to settlers at Lagao by June, 1940. Reports from the settlement recently show that settlers have been able to raise their first crops from their farm lots.

THE SETTLER'S BALANCE SHEET

To maintain these new settlements with over 1,500 members, excluding the officials and employees, required a heavy outlay during the first year when efforts were concentrated in establishing new communities in hitherto unoccupied land. Furthermore, farm lots

were not then ready for distribution and the settlers were not yet on production basis. All energies were brought to bear in building modest dwellings and in cultivating and planting vegetables in garden or home lots. Many of these garden lots were in full production at the time of the visit and even at Tupi many homes were already producing very much more vegetables than could be consumed, with the result that a marketing problem will eventually prove a serious one. If reports are correct, the National Development Corporation is said to be planning to operate a canning plant at Koronadal partly perhaps because at this stage of production, this problem

Fig. 4.—A farm machinery shed at Lagao.

that was observed last year must have reached sufficiently serious proportions.

Upon arrival, the settler with his family has to subsist and he gets his absolute necessaries from the administration store chargeable against the sum allowed him which does not exceed ₱1,200. This amount was reduced at the time of the visit to ₱600. He builds a house, buys farm and garden tools, and work animals. As he was not able to earn anything during the first year, excepting for occasional work performed for the administration which paid him wages

from ₱0.60 to ₱0.80 a day, not in cash but credited to his account, his first year showed a relatively heavy debit balance.

Thus, in Lagao, table 1 shows that while the majority of the settlers had incurred indebtedness under ₱300, 9 settlers had passed the ₱500 mark, and 23 had incurred a net indebtedness of over ₱600. Total obligations of all the settlers at Lagao on January 31, 1940, was ₱54,085, or an average of ₱183.00 per settler. Excluding those who resigned and those who had small credit balances, the average indebtedness of 206 settlers was ₱254.00.

In Tupi, the obligations of settlers were relatively much lower as shown in table 2. The majority had debts under ₱100 and only 11 had obligations between ₱200 and ₱400. The average low indebtedness of settlers at Tupi was due to the fact that the settlement was only about half a year old and that houses constructed there with local materials cost the settlers very little. The total indebtedness of all settlers was ₱9,048.83, or an average of about ₱63.00 for each settler. Excluding those who resigned and those who had small credit balances, the average indebtedness of 131 settlers was ₱69.00.

Table 3 shows the distribution of expenditures as shown by the classified accounts of some of the heavily indebted settlers. It will be seen that food, construction of a house, and transportation comprise about 90 per cent of the indebtedness of a settler. Expenses for food, other than vegetables raised in the garden, as indicated by his accounts with the administration show that, on the average, even those settlers who were heavily indebted spent monthly from ₱15 to ₱22 for food. Under the circumstances, the average settler certainly does not indulge in luxury, for the administration in an effort to keep the indebtedness below the maximum, reduces the advances even in food articles to bare essentials.

From the trend of indebtedness of settlers, especially at Lagao, it is apparent that settlers cannot afford to lose time in putting their farms on a productive basis. At the time of the visit, attention was concentrated to speeding up the survey and distribution of farm lots so as to make the settlers self-sufficient as quickly as possible and thus gradually ease the burden that the administration had to carry during the first year.

SUMMARY

Koronadal is the first attempt at organized land settlement on a large scale under government direction and support. Attempts at

selection of settlers, adequate financial support to put newly-opened farms on a production basis, the building of model communities with a view of developing a sound rural social life, sustained guidance, and technical advice are all comprised in the scheme to bring about the rapid settlement of the public domain and the solution of the economic and social problems that plague congested areas of the Philippines.

The results accomplished during the first year, considering the difficulties of a new organization in working out solution to a multitude of problems that usually beset a new enterprise, are most encouraging. Nearly 400 settlers with members of their families, totalling 1,500, have been established in new homes with garden lots of one-fifth hectare, for each settler. Most of these gardens were already planted to vegetables for the support of the family. Administration farms have been planted, crops harvested, farm lots in process of sub-division, all within the brief period of one year from the opening of the settlement.

The balance sheet of the settler showed that on the average, during the year, his indebtedness was under ₱200. While it is true that a number of settlers have run up obligations nearing the maximum of ₱600, the opening of the farm lots for production during the second year, 1940, would help reduce the indebtedness gradually. The necessity of rapidly distributing farm lots to settlers and of putting them on a production basis so as to improve their financial position will be one of the main tasks of the National Land Settlement Administration.

There is hardly any doubt as to the success of the settlement plan; already reports come that in the second year, 1940, the number of settlers have gone up to 2,500 with families numbering nearly 9,000. Crops have been harvested and settlers have commenced paying up their obligations. The financial statement of the National Land Settlement Administration, in December 31, 1940 showed that a total of ₱795,000 has been advanced to the 2,500 settlers, or an average indebtedness of ₱318.00 for each settler.

TABLE 1

Indebtedness of settlers, Lagao settlement, as of January 31, 1940

	NUMBER OF SETTLERS
Under ₱50	48
₱ 50 — ₱ 99	14
₱100 — ₱199	33
₱200 — ₱299	35
₱300 — ₱399	27
₱400 — ₱499	18
₱500 — ₱599	9
₱600 and over	22
	206
Settlers with small credit balances	37
Settlers resigned	31
Total	274
INDEBTEDNESS OF SETTLERS WHO RESIGNED	
Under ₱10	6
₱ 10 — ₱ 19	4
₱ 20 — ₱ 29	4
₱ 30 — ₱ 49	3
₱ 50 — ₱ 99	1
₱100 — ₱199	3
₱200 and over	1
Settlers with credit balances	9
Total	31

TABLE 2

Indebtedness of settlers, Tupi settlement, as of January 31, 1940

	NUMBER OF SETTLERS
Under ₱50	76
₱ 50 — ₱ 99	32
₱100 — ₱199	12
₱200 — ₱299	8
₱300 — ₱399	3
	131
Settlers with small credit balances	8
Settlers resigned	5
Total	144

INDEBTEDNESS OF SETTLERS WHO RESIGNED

Under ₱10	3
₱10 — ₱19	1
₱20 — ₱29	0
₱30 — ₱49	0
₱50 — ₱59	1
Total	5

TABLE 3

Distribution of expenditures of some of the heavily indebted settlers

SETTLER	FOOD AND MESS ACCOUNT	CLOTHING	CONSTRUCTION MATERIALS	PLANTING MATERIALS	TRANSPORTATION	FARM IMPLEMENTS	WORK ANIMALS	MISCELLANEOUS	TOTAL DEBITS	CREDITS	NET DEBT
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
A	207.12	23.00	425.63	4.88	48.00	19.57		43.85	771.78	154.00	617.38
B	140.57	31.18	302.42	16.20	86.53	15.76		72.92	665.38	71.67	593.71
C	141.63	23.87	152.19	38.72	81.60	12.41	73.00	52.61	576.03	66.90	509.13
D	199.50	32.11	267.86	5.88	96.00	9.31	86.34	139.86	836.86	117.70	719.16
E	227.77	39.66	286.26	27.50	58.54	12.04		74.34	726.11	123.60	602.51
F	265.88	23.00	297.23	19.13	179.16	17.47	86.34	160.44	1048.65	23.02	1025.63
G	192.38	29.57	370.57	.23	94.50	23.43		93.87	803.57	116.70	686.87

COLLEGE AND ALUMNI NOTES

Dr. Santiago R. Cruz of the Department of Agricultural Engineering reported for duty on June 2 after an absence of almost three years in the United States as a University fellow. Dr. Cruz pursued advanced studies at Cornell University where he obtained the degrees of Master of Science and Doctor of Philosophy. He was elected to the honor societies of Sigma Xi and Phi Kappa Phi.

This year's opening exercises of the College were held at Baker Memorial Hall on June 9. Dr. Francisco M. Sacay spoke in behalf of the faculty and Lelis C. Loria, of the students. Dr. Miguel Manresa made the opening remarks and Dean L. B. Uichanco welcomed the students.

Mr. Getulio B. Viado, assistant instructor in entomology at this College who is now detailed to the United States as a U. P. fellow in entomology, is expecting to leave for the Philippines with a doctorate of philosophy from the Iowa State College before July 15. He has been elected to the Sigma Xi and to the honorary chemical society Phi Lambda Upsilon.

The enrollment in the College this year is 504, smaller than last year's by 57. The Rural High School has 163 students, exceeding last year's enrollment by 5. Nine girls are enrolled in the College and 26 in the high school.

The graduation of ten students was approved at the meeting of the faculty on Tuesday, June 17. For the degree of Bachelor of Science in Agriculture: Valentin G. Cedillo, Cecilio T. Cornelia, Simeon B. Dizon, Romeo L. Escuadra, Emilio T. Gamatero, Andres P. Navarro, and Modesto G. Tayag; for the certificate in Agricultural Education: Nicolas C. Camello; for the title of Associate in Agriculture: George E. Cawley and Silvestre A. Pablo.

Miss Pacita L. Samaniego joined the faculty as a teacher of English at the Rural High School vice Prof. Emilio M. del Rosario who is detailed to the Department of English of the College. Prof. del Rosario is taking the place of Prof. R. M. Mack who is on leave and is now in the United States.

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS

Circular No. 2.—**Bud Rot of Coconut (Revised, June, 1934)** - - - *By G. O. Ocfemia*

Circular No. 3.—**Experimental Errors and Application of the Probable Error to and the Interpretation of Experimental Results** - - - - - - - - - - - - *By Nemesio B. Mendiola* (Published as Chapter IV in *A Manual of Plant Breeding for the Tropics*, 1926, also sold by THE PHILIPPINE AGRICULTURIST at ₱3.25, paper bound, and ₱5.25, cloth bound, in the Philippines, and ₱3.50 and ₱5.50 elsewhere, postpaid.)

Circular No. 5.—**Poultry Raising Made Easy (Revised)** - - - - *By F. M. Fronda*

Circular No. 7.—**How to Produce New Varieties of Gumamela (Hibiscus)** - - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 8.—**Horse Breeding in the Philippines** - - - - - *By Valente Villegas*

Circular No. 9.—**Fences for Farm Animals** - *By B. M. Gonzalez and J. P. Esguerra*

Circular No. 10.—**Practical Directions for Coffee Planting** - - - *By Pedro A. David*

Circular No. 11.—**The New College Copra Drier**—Prepared in the *Department of Agricultural Chemistry* with the cooperation of the *Department of Agronomy and Extension.* (Revised by *Moises M. Kalaw*).

Circular No. 14.—**Beriberi: Its Causes and Prevention** - - - - - *By F. O. Santos*

Circular No. 15.—**Cattle Raising under Philippine Conditions** - - *By Valente Villegas*

Circular No. 16.—**A Simple Farm Record for the Farmer** - - *By Francisco M. Sacay*

Circular No. 17.—**College Trapnest** - - - - - - - - *By F. M. Fronda and P. S. Paje*

Circular No. 18.—**Surveying for Area with a Surveyor's Staff** - *By Alexander Gordon*

Circular No. 19.—**A Pageant: Illustrating the History and Growth of the College of Agriculture** - - - - - - - - - *By Anne F. Cole*

Circular No. 20.—**Amount of Nutrients in Philippine Food Materials** - - - - - - - - *By F. O. Santos and S. J. Ascalon*

Circular No. 21.—**Cassava Growing and Cassava Starch Manufacture** - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 22.—**Goat Raising** - - - - - - - - - - - - - - - *By Valente Villegas*

Circular No. 23.—**Curing Pork and Making Sausage for Home Use** - - - - - - - - - - - - - - - - *By Mariano Mondoñedo*

Circular No. 24.—**Construction and Operation of Silos in the College of Agriculture** - - - - - - - - - - - - *By José P. Esguerra*

Circular No. 26.—**Training Cattle and Carabaos for Work** - - - *By Valente Villegas*

Circular No. 27.—**Bunchy-top of Abacá** - - - - - - - - - - - - *By G. O. Ocfemia*

Circular No. 28.—**Cotton Culture** - - - - - - - - - - - - - *By Eulalio P. Baltazar*

Circular No. 29.—**Collegiate Education in Agriculture** - - - - *By L. B. Uichanco*

Circular No. 30.—**What Should Filipino Ornamental Gardens and Ornamental Plants Be?** - - - - - - - - - - *By N. B. Mendiola*

Circular No. 31.—**How to Slaughter and Dress Farm Animals** - - - - - - - *By Valente Villegas and M. Mondoñedo*

The price of the Circulars listed above is 10 centavos each except Nos. 5, 10, 16, 21, and 30 which cost 20 centavos apiece.

ALL ORDERS SHOULD BE ADDRESSED TO THE BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, AGRICULTURAL COLLEGE, LAGUNA, PHILIPPINES